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USER'S MANUAL FOR THE DEFÉNSE PRIORITY MODEL

VERSION 2.0

J.M. HUSHON, Ph.D.,
R. ABBUHL and
N.S. PANDIT, P.E.
Roy F. Weston, Inc.
955 L'Enfant Plaza, S.W.
Washington DC 20034

ARTHUR KAMINSKI, Capt, USAF

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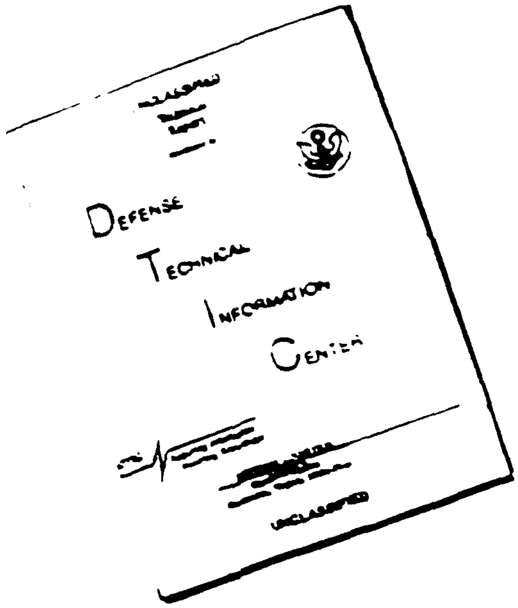

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DEFENSE PRIORITY MODEL

USER'S MANUAL

VERSION 2.0

REV 1

OFFICE OF THE DEPUTY ASSISTANT
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Prepared by
Roy F. Weston, Inc.
955 L'Enfant Plaza, SW
Washington, DC 20024

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The "Defense Priority Model" (DPM) is intended to permit the use of site-specific monitoring data to refine priorities for remedial actions.

In DPM, the health and ecological hazards of contaminants identified through monitoring are assessed using toxicological benchmarks and/or bioaccumulation factors that relate the concentrations measured to concentrations or doses that may be toxic. This user's manual provides (1) detailed instructions for rating contaminated sites using DPM, (2) worked-out examples of DPM applications, (3) lists of toxicity benchmarks and/or bioaccumulation factors for hazardous chemicals identified at Air Force installations, and (4) blank score sheets.

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Many people contributed to the development of the Defense Priority Model (DPM) and this user's manual. The users manual for the first version of DPM was developed by Ellen Smith and Lawrence Barnthouse of Oak Ridge National Laboratory. Since that time, the model has been extended by Roy F. Weston, Inc. to include the air and soil pathways. The text of this user's manual is an amalgam of text prepared by both groups, and both are acknowledged as significant contributors. DPM would not have been possible without the efforts of Glenn W. Suter II, Troyce D. Jones, and James E. Breck of ORNL, who developed the protocols for selecting toxicological benchmarks and bioaccumulation factors for use in DPM, calculated or located many of the values reported in Appendix B, and freely shared their thoughts on the structure of the methodology. Clay Easterly, Bruce A. Owen, and Annetta P. Watson of ORNL also provided invaluable assistance in determining human health toxicological benchmarks for contaminants reported at Department of Defense facilities. In addition, Morris Trichon, Randall Abbuhl, Richard Craig, George Mikroudis, and Jack Ditmars of Weston provided valuable inputs into the modeling of the air and soil pathways and the restructuring of the system to improve its functionality.

DPM has undergone several test applications, each of which led to refinements in the methodology and improvements in this user's manual. We are grateful for the contributions of the various individuals and organizations that participated in or assisted us in these tests.

The development and testing of DPM were sponsored by the U.S. Air Force Occupational and Environmental Health Laboratory (OEHL), Brooks Air Force Base, Texas. Dee Ann Sanders, Major George New, and Captain Art Kaminski, the OEHL project officers, deserve special thanks for their assistance and support.

ABSTRACT

The "Defense Priority Model" (DPM) is intended to permit to the use of site-specific monitoring data to refine priorities for remedial action.

In DPM, the health and ecological hazards of contaminants identified through monitoring are assessed using toxicological benchmarks and/or bioaccumulation factors that relate the concentrations measured to concentrations or doses that may be toxic. The user's manual provides (1) detailed instructions for rating contaminated sites using DPM, (2) worked-out examples of DPM applications, (3) lists of toxicity benchmarks and/or bioaccumulation factors for hazardous chemicals identified at DoD installations, and (4) blank score sheets.

An automated version of DPM (ADPM), that runs on a PC and assists the site scorer, is available.

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LIST OF FIGURES

LIST OF TABLES*

*The numbers in the square [ ] brackets refer to item numbers used on the score sheets in Appendix A.

EXECUTIVE SUMMARY

Under the Superfund Amendments and Reauthorization Act of 1986 (SARA) and Executive Order 12580, "Superfund Implementation," the Department of Defense has authority and responsibility for conducting an Installation Restoration Program (IRP) to address environmental contamination from past waste sites on its installations. Program management is centralized in the Office of the Deputy Assistant Secretary of Defense (Environment), and each of the military departments implements its own IRP at its installations.

Department of Defense policy is to address the worst sites first. A DoD wide priority system is needed to ensure that resources are applied first to sites which present the greatest potential threat to human health and the environment. DoD has developed the Defense Priority Model (DPM) to assist decision makers in identifying priorities for remedial action and to aid in future year budget development.

The DPM will be applied to DoD sites after a remedial investigation/ feasibility study (RI/FS) (40 CFR 300) has been conducted and the site has been fully characterized. The model is a mathematical algorithm which computes a numerical score (zero to 100) representing the potential threat to human health and the environment based on contaminant pathway, hazard, and receptors. Other pertinent information such as mission impact, community concerns, regulatory considerations, and program efficiencies will be used by DoD decision makers to determine the relative priority of a site for remedial action.

This DPM manual updates a December 1987 version and reflects changes to the model by DoD in response to comments from the Environmental Protection Agency and states. The DPM is not intended to replace the Hazard Ranking System (HRS) used by the Environmental Protection Agency (EPA) to evaluate sites based on data collected during a preliminary assessment/site inspection (PA/SI) (40 CFR 300). DoD anticipates that the EPA will continue to apply the HRS to DoD facilities to determine whether they warrant inclusion in the National Priorities List (NPL) of hazardous waste sites.

This user's manual provides detailed instructions for rating sites using DPM. It is intended that, with the aid of this manual, DPM can be applied by mid-level technical personnel with backgrounds in environmental engineering, but without extensive experience in modeling, toxicology, or hydrogeology. The DPM scoring procedure has been automated to facilitate scoring. A separate user's manual has been prepared for the automated version.

Section 1 of the manual presents an overview of DPM. Sections 2, 3, and 4 present, respectively, instructions for calculating subscores to characterize hydrologic transport pathways, contaminant hazards, and potential receptors associated with contaminated sites. Separate subscores are calculated for each of six combinations of potential transport pathways and potential receptors: (1) human receptors of surface water contaminants, (2) ecological receptors of surface water contaminants, (3) human receptors of ground water contaminants, and (4) ecological receptors of ground water contaminants,

(5) human receptors of air and soil contaminants, and (6) ecological receptors of air and soil contaminants. Section 5 describes the algorithms used to aggregate subscores to obtain a single overall rating for each contaminated site.

Appendix A presents blank score sheets for DPM and examples of the application of DPM to representative contaminated sites, including completed examples of all the necessary score sheets.

Appendix B provides toxicological benchmarks and bioaccumulation factors for approximately 200 potentially toxic nonradiological chemicals and chemical mixtures identified at Air Force, Navy, and Army facilities. Values are also provided for other nonradiological contaminants that are often associated with contaminated sites. These benchmarks and the methods used to derive them are documented in a separate report (Barnthouse, et al., 1988. Appendix C presents a cross-referenced list of chemicals by Chemical Abstracts Service (CAS) number. Appendix D provides additional chemical data required for scoring the air/soil pathway. Appendix E contains the list of Air Force installations for which meteorology data are available in the ADPM.

Appendix F contains a list of the site data required to complete the DPM scoring. This can be used as a checklist for locating the information prior to scoring.

Appendix G serves as a user's manual for the automated version of DPM (ADPM) that runs on a PC/AT or equivalent.

Appendix H serves as background on the methodologies used to compute health and ecological benchmarks. This appendix can be useful if benchmarks are not available in Appendix B. Appendix I contains an explanation of the air/soil pathway computations.

1. INTRODUCTION

1.1 OVERVIEW OF THE DEFENSE PRIORITY MODEL

The Department of Defense (DoD) Installation Restoration Program (IRP) requires the identification and evaluation of past disposal sites on DoD installations and the control of adverse effects on human health and the environment from those sites. The military departments implement the IRP at their own installations, consistent with the process described in the National Oil and Hazardous Substances Pollution Contingency Plan, (the NCP), 40 CFR 300. The basic steps in this process can be described generally as: preliminary investigation/site inspection (PA/SI), remedial investigation/feasibility study (RI/FS), and remedial design/remedial action RD/RA).

The Defense Priority Model (DPM) is intended to permit the use of site specific data collected during the PA/SI and RI/FS steps to determine priorities for remedial action. The DPM provides a numerical score which represents the potential threat to human health and the environment. Like other ranking systems, separate subscores are calculated for each of six combinations of potential transport pathways and potential receptions: (1) human receptors of surface water contaminants; (2) ecological receptors of surface water contaminants; (3) human receptors of ground water contaminants; and (4) ecological receptors of ground water contaminants, (5) human receptors of air and soil contaminants, and (6) ecological receptors of air and soil contaminants. Separate assessments for ground water, surface water pathways, air and soil pathways; and for human health and ecological receptors are calculated since the contaminants that pose an ecological risk are often different from those that pose a human health risk. The subscores are then combined into an overall site score. A flowchart for scoring sites using the DPM is presented in Figure 1.

DPM assesses the health and ecological hazards of contaminants identified through monitoring using toxicological benchmarks that: (1) rank toxic chemicals according to their relative toxicity and; (2) relate the concentrations measured at a site to concentrations or doses that may be toxic.

The DPM does not evaluate all factors related to risk, and therefore, may yield false high scores for some sites. Determination of contaminant mobility has been judged to be too complex to accurately describe in the DPM, so all contaminants are treated as if they were equally mobile. As a result, a site contaminated with polychlorinated biphenyls (PCBs) or dioxin might receive a high score on a ground water pathway, but because these substances are relatively immobile in most soils there might be very little possibility that the contaminants would reach ground water. Because it is thus possible to assign unrealistically high DPM scores, priorities for further action are not based exclusively on the DPM score. Instead, the DPM score is considered along with additional information such as mission impact, community concerns, regulatory considerations, and program efficiencies.

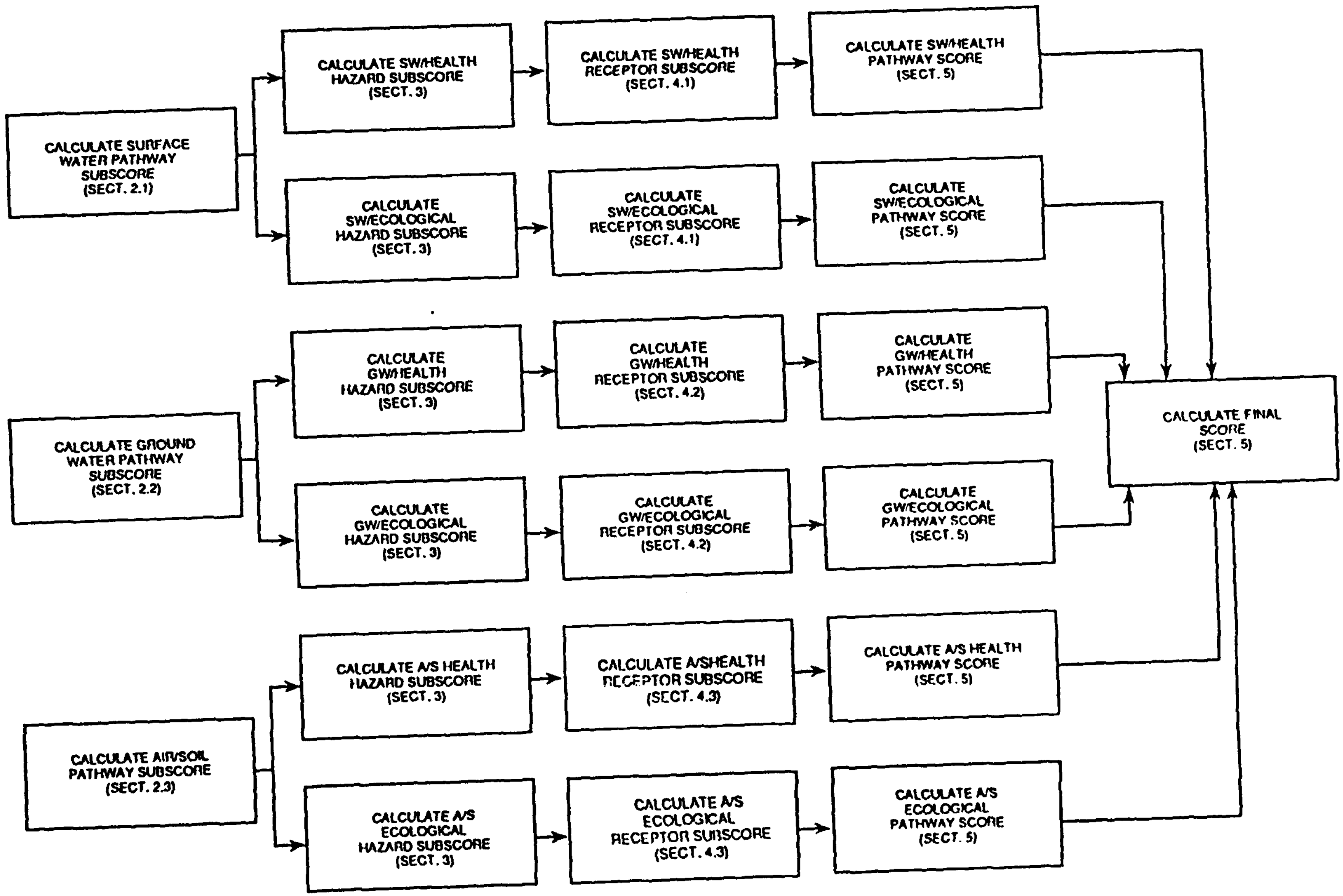

FIG. 1 FLOW CHART FOR THE DEFENSE PRIORITY MODEL

This user's manual provides detailed instructions for rating sites using DPM. It is intended that, with the aid of the manual, DPM can be applied by mid-level technical personnel with background in environmental engineering or sciences, without extensive experience in modeling, toxicology, or hydrogeology.

1.2 CONTENTS OF THE USER'S MANUAL

Sections 2, 3, and 4 of this manual present, respectively, detailed instructions for calculating pathways, contaminant hazard, and receptors scores for contaminated sites. To assist the user in following the instructions for scoring, the item numbers used on the score sheets (Appendix A) are given in brackets [ ]. Readers of these sections should refer to the appropriate score sheets for instructions on combining scores for individual items to obtain DPM subscores. Section 5 describes the algorithms used to aggregate scores and subscores to obtain overall site ratings. The DPM scoring system has been implemented on a microcomputer program.

Appendix A presents blank scoring sheets together with example applications of DPM to representative contaminated sites. To facilitate application of DPM by personnel without specific expertise to toxicology, Appendix B lists human health hazard benchmarks, ecological hazard benchmarks, and bioaccumulation factors for approximately 200 contaminants identified at Air Force, Navy, and Army facilities. These values, which are required to calculate hazard scores, are documented in detail by Barnthouse, et al., (in press). As an aid in locating benchmarks for chemicals with multiple names, Appendix C contains a listing of all chemicals by Chemical Abstracts Service (CAS) number. Appendix D presents additional chemical data for air/soil pathway scoring. Appendix E contains a list of Air Force installations for which meteorology data are available. Appendix F contains a list of site data required to run DPM. The user's manual for the automated DPM (ADPM) is included as Appendix G. Appendix H describes the methodology for calculation of health and ecological effects benchmarks and Appendix I describes the air/soil pathway methodology.

1.3 GENERAL GUIDANCE FOR APPLYING DPM

The quality of the site ratings produced by DPM is critically dependent on the quality of the information used as basis for scoring and the consistent application of the method. Where several sources of data exist for scoring a particular item, DPM scores should be based on site-specific measurements or observations instead of regional-scale data, on quantitative instead of qualitative data, and on measurements that have been subjected to appropriate quality assurance checks instead of unverified data. Regardless of the source of the information used, all information sources should be documented in the "comments" sections of the score sheets or on separate pages, together with any assumptions made in scoring. The text of the user's manual should be regarded as the primary source of guidance on definitions of scoring items and terms in DPM.

In most cases, the user of DPM must rely primarily on information collected and reported by others. This secondary information (e.g., from IRP reports) consists of both direct observations (e.g., measurements of chemical concentrations in surface water and ground water) and interpretations (e.g., investigators' opinions as to whether measured concentrations exceed background levels). Uncritical adoption of interpretations made by others could lead to inconsistency in DPM scoring, because different standards of judgment than are required for DPM may have been used. Therefore, DPM users should attempt to verify secondary interpretations by checking them against the information upon which they are based. Data and interpretations from third parties (e.g., measurements by the EPA or a state agency of contaminant concentrations in off-site wells) present a special problem. In general, direct observations by reliable third parties should be considered in scoring, but caution should be exercised in handling third-party interpretations.

2. PATHWAYS SCORING

The pathways portion of the DPM methodology rates the potential for contaminants from a waste site to enter surface waters via overland flow routes or to enter ground water.

2.1 SURFACE WATER PATHWAYS

2.1.1 Observed Releases [1]

If contaminants from the rated site have already been detected in surface waters, assign a score of 100 for this factor and proceed directly to the rating of waste containment effectiveness for surface water pathways (sect. 2.1.3). Otherwise, assign a score of zero and proceed to the scoring of pathway characteristics (sect. 2.1.2).

A finding that contaminants have been detected must be based on (1) at least one analytical determination in which contaminants were present in surface water at a level that represents a significant (in terms of demonstrating that contamination has occurred, not in terms of potential effects) increase above background, and (2) an indication (e.g., due to physical locations and/or nature of contaminants) that the contaminants migrated from the rated site via surface transport routes. If only one of several analyses indicated contamination and there is a good reason to suspect the validity of the analytical result, assign a score of zero and note the reason for this score in the "Comments" section. If contaminants detected in surface waters are equally likely to have come from several sources, assign a score of zero and note the reason for this score in the "Comments" section.

2.1.2 Pathway Characteristics

Distance to nearest surface water [2] is the shortest distance from the waste site or contaminated area to the nearest downslope body of surface water that is on the course that runoff can be expected to follow. "Surface waters" include lakes, perennial and intermittent streams, the oceans and arms of the oceans, and drainage ditches that connect with other surface waters. Other low areas that contain water for only a short time after rainfall events and that do not drain to another body of surface water are included in areas where annual precipitation is less than 20 in. (508 mm). Assign a score as follows:

Distance [2]	Score
>1 mile (>1.7 km)	0
2001 ft to 1 mile (610 m to 1.7 km)	1
501 ft to 2000 ft (153 to 610 m)	2
0 to 500 ft (0 to 153 m)	3

In the "Comments" section of the score sheet, identify the body of surface water and the distance upon which the score is based.

Net precipitation [3] is an indicator of the potential for leachate generation. It is defined as average annual precipitation minus average annual lake evaporation. If "net seasonal rainfall" values (i.e., seasonal rainfall minus seasonal evaporation) are reported for the site area, these values should be used to determine total annual net precipitation. Where possible, the evaporation and precipitation values used in this calculation should be obtained from local meteorological stations. If local data are unavailable, values should be obtained from Figures 2 and 3. Assign a score as follows:

Net precipitation [3]	Score
<-10 in. (<-254 mm)	0
-10 to +5 in. (-254 to +127 mm)	1
+5 to +20 in. (+127 to +508 mm)	2
>+20 in. (>+508 mm)	3

Indicate the basis for scoring in the "Comments" section of the score sheet.

Surface erosion potential [4] is a measure of the potential for erosion processes to detach and transport contaminant particles or contaminated soils. Evaluation of surface erosion potential is based on a combination of factors, including field evidence of past erosion, steepness of surface slope, length of slope, slope convexity or concavity, particle size distribution, and vegetative cover. Table 1 provides general guidance for characterizing surface erosion potential. If field evidence (i.e., site inspections, site photographs, or inspection reports) indicates greater surface erosion than would be expected from site characteristics, the evaluation of erosion potential should be based on the field evidence. Engineered features which reduce the potential for surface erosion (e.g., roofs and pavements) should not be considered in evaluating this factor; they are taken into account later in evaluating waste containment effectiveness (sect. 2.1.3). If, however, the topography is different from the natural topography (e.g., many landfills are above-grade mounds and have greater slopes than the surrounding landscape), consider the modified topography when scoring surface erosion potential.

Assign a score for surface erosion potential as follows:

Surface erosion potential [4]	Score
None	0
Slight	1
Moderate	2
Severe	3

Note the basis for scoring in the "Comments" section of the score sheet.

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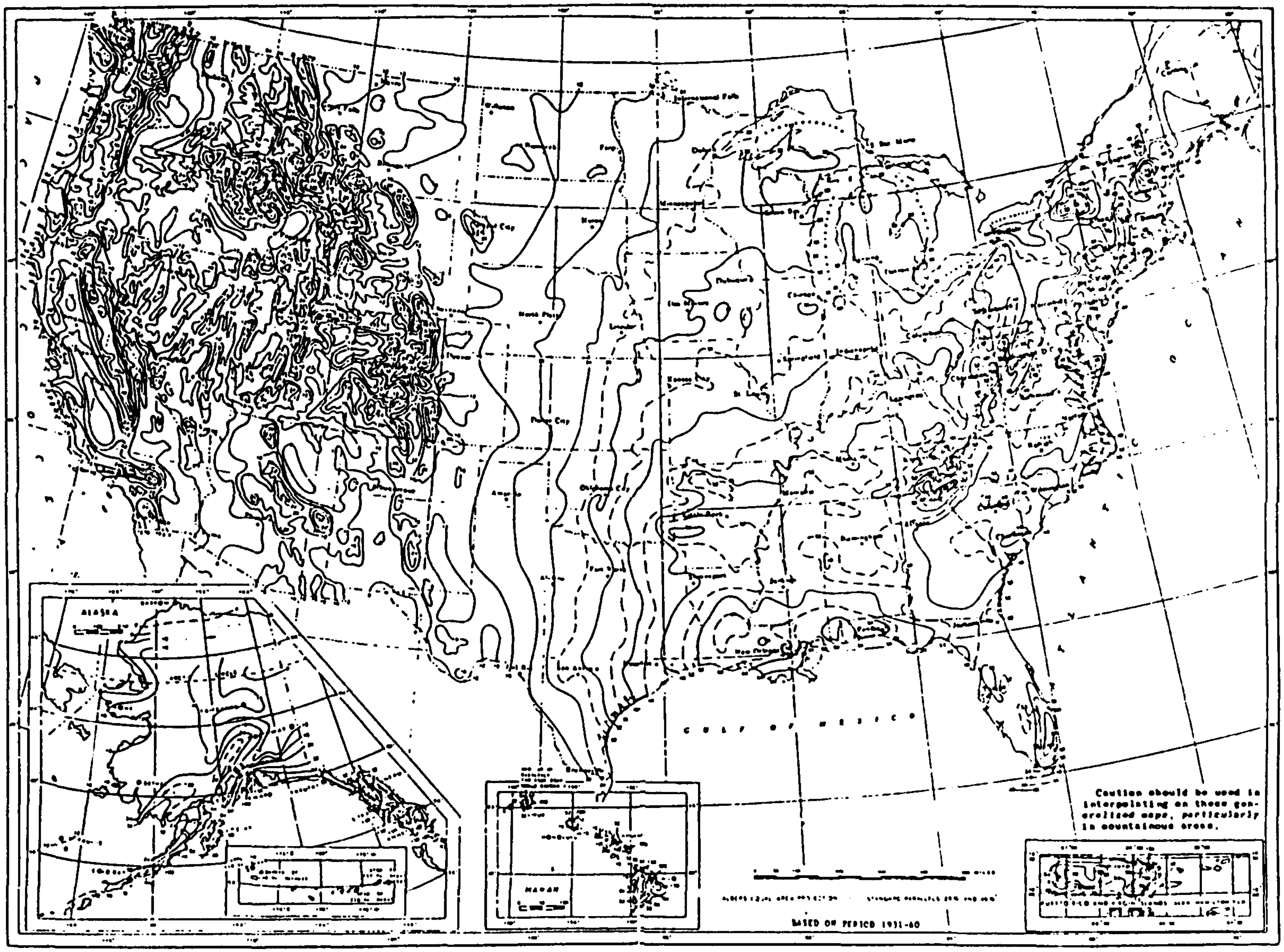

Fig. 2. Normal annual total precipitation. Source: J. L. Baldwin. 1968. Climatic Atlas of the United States. U.S. Dept. of Commerce, Environmental Sciences Services Administration, Environmental Data Service. (Reprinted in 1975 as "Weather Atlas of the United States" by Gale Research Co., Detroit, MI.)

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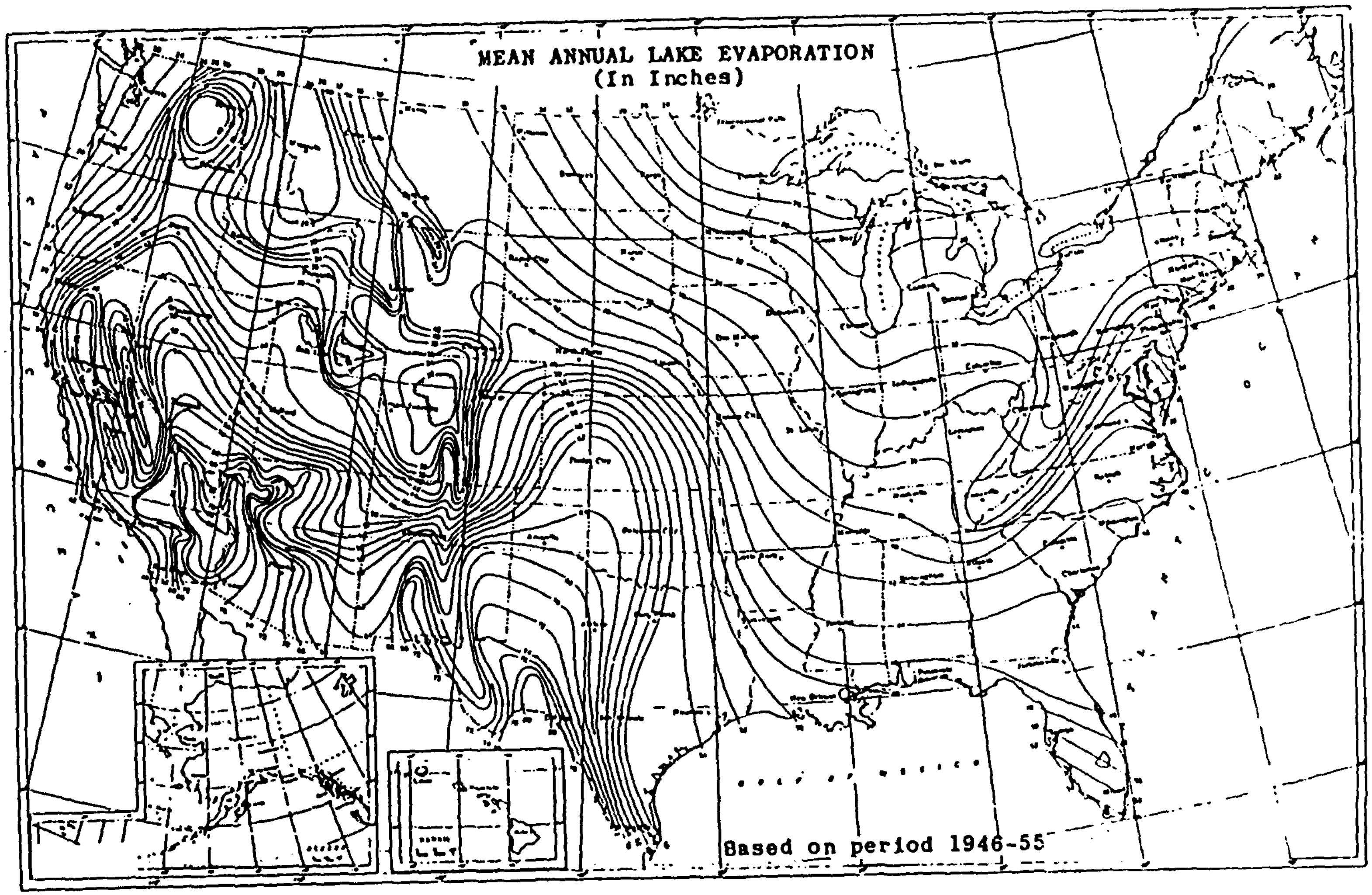

Fig. 3. Mean annual lake evaporation. Source: J. L. Baldwin. 1968. Climatic Atlas of the United States. U.S. Dept. of Commerce, Environmental Sciences Services Administration, Environmental Data Service. (Reprinted in 1975 as "Weather Atlas of the United States" by Gale Research Co., Detroit, MI.)

Table 1. Guidance for characterizing soil erosion potential [4]

None	This characterization should be used only in cases in which contaminants are confined within an enclosed depression below the surrounding grade. Thus, a below-grade pit would be characterized as having no surface erosion potential, but a liked above-grade surface impoundment should be evaluated on the basis of the surrounding topography and soils.
Slight	Sites with "slight" erosion potential do not exhibit visible rills or gullies. Sites with surface slopes of 2% or less should be characterized as having "slight" erosion potential, unless the surface lacks vegetative cover and is unusually susceptible to erosion due to the particle size of the surface material (i.e., silt, very fine sand, or material classified as "ML" in the Unified Soil Classification System) or the length of the slope. Somewhat steeper sites (e.g., slopes up to about 6%) also would typically be classified as having "slight" erosion potential if they have well-established grass or forest cover.
Moderate	Typical field evidence of "moderate" erosion might consist of a low density of rills and gullies. Sites with surface slopes of 6 to 12% and good vegetative cover should generally be classified as having "moderate" erosion potential, as should sites with 2 to 6% slopes that are not well vegetated. Sites with slopes as high as 15% may be characterized as having "moderate" erosion potential if the slopes are concave, slope length is less than 300 ft (90 m), and the sites support well-established grass or forest vegetation.
Severe	Sites with "severe" erosion potential are those where field inspection has revealed evidence of extensive rills and gullies, or where long, steep surface slopes, poor vegetative cover, and other factors suggest a high surface erosion potential. In general, sites with surface slopes of 15% or greater have "severe" erosion potential. Most unvegetated or poorly vegetated sites with slopes of 6% or greater should be characterized as having "severe" erosion potential.

Rainfall intensity [5] indicates the potential for storms to cause contaminant releases into surface water as a result of runoff, erosion, flow over dikes, or breaching of impoundment dikes. Scoring is based on the 1-year 24-hour rainfall, obtained from Figure 4. Do not score on the basis of the "maximum" 24-hour rainfall. For sites outside the continental United States, the 1-year 24-hour rainfall amount should be obtained from the facility engineering office. If this amount has not been determined, the 24-hour rainfall with a return period of 1 year should be estimated from facility meteorological records. Assign a score as follows:

1-year 24-hour rainfall [5]	Score
<1.0 in. (<25 mm)	0
1.0 to 2.0 in. (25 to 51 mm)	1
2.1 to 3.0 in. (52 to 76 mm)	2
>3.0 in. (>76 mm)	3

Note the basis for scoring in the "Comments" section of the score sheet.

Surface permeability [6] is an indicator of the potential for precipitation to lead to surface runoff. Lower surface permeabilities are associated with greater runoff. Surface permeability may be estimated from (in descending order of preference) field or laboratory determinations of soil permeability, soil survey reports that report soil percolation rates, or soil particle size distributions. The presence of any engineered containment structures that modify surface permeability should not be considered in evaluating this factor. Assign a score as follows:

Surface permeability [6]	Score
$>10^{-2}$ cm/s (or <15% clay)	0
10^{-2} to 10^{-4} cm/s (or 15-30% clay)	1
10^{-4} to 10^{-6} cm/s (or 30-50% clay)	2
$<10^{-6}$ cm/s (or >50% clay)	3

Note the basis for scoring in the "Comments" section of the score sheet.

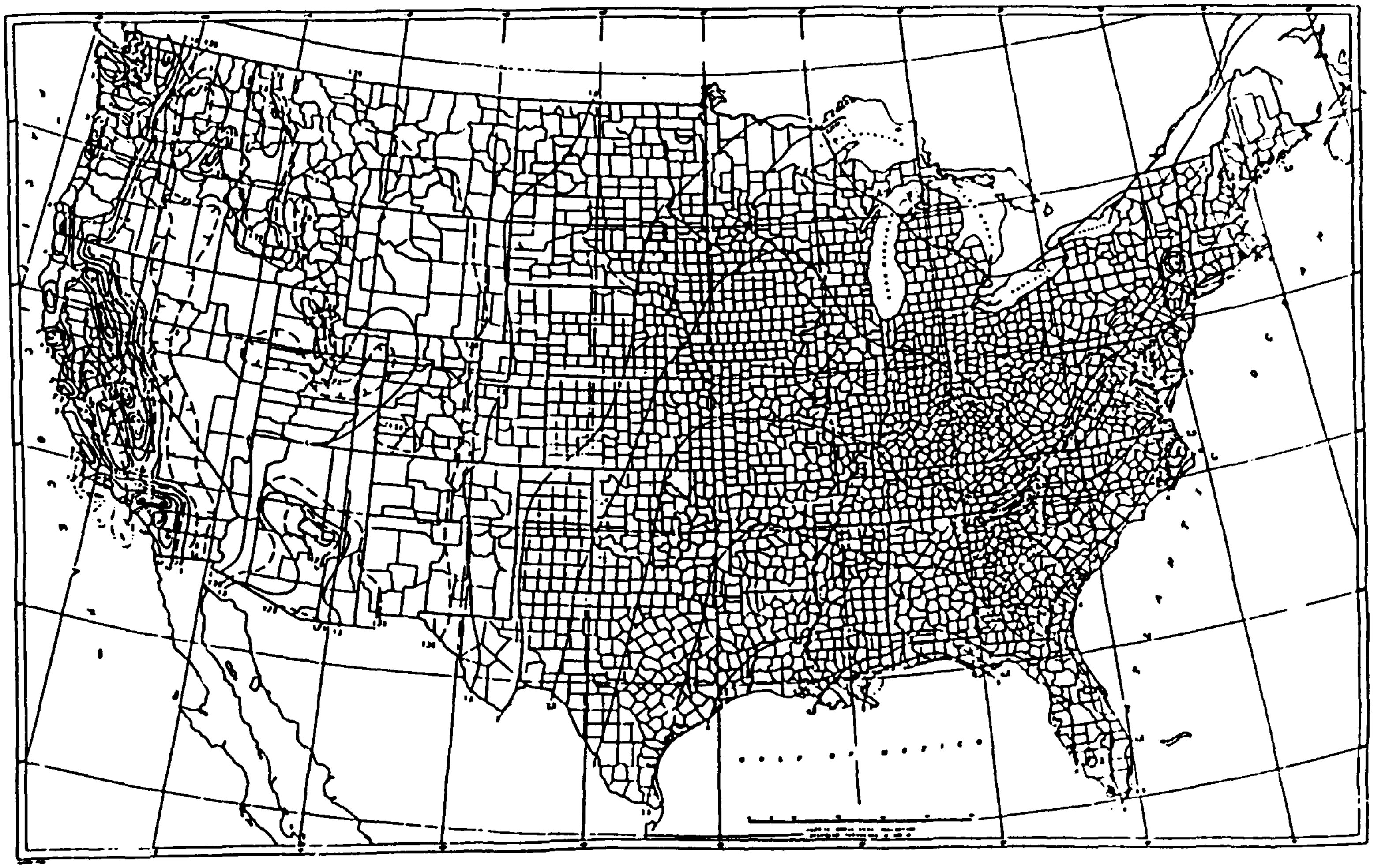

Fig. 4. 1-year 24-hour rainfall. Source: D. M. Hershfield. 1961. Rainfall Frequency Atlas of the United States. U.S. Weather Bureau Technical Paper 40. U.S. Dept of Commerce. U.S. Government Printing Office, Washington, DC.

Flooding potential [9] is a measure of the potential for contaminants to be transported by flood waters. Flooding potential is measured by the frequency (observed or estimated) of inundation due to stream flooding, coastal flooding, high lake levels, or other causes. Facility engineering offices should be contacted to obtain floodplain maps or engineering reports that provide the information needed to evaluate this factor. County or state agencies responsible for planning, zoning, or floodplain management may also be able to supply relevant information. Assign a score as follows:

Flooding potential [9]	Score
Beyond 100-year floodplain	0
In 100-year floodplain, beyond the 25-year floodplain and the 100-year floodway	1
In 25-year floodplain or 100-year floodway, beyond zone of annual flooding	2
Floods annually	3

Note the basis for scoring in the "Comments" section of the score sheet.

2.1.3 Waste Containment Effectiveness [11]

The waste containment effectiveness multiplier adjusts the pathways score to account for the effectiveness of engineered barriers or clean-up actions in reducing the potential for contaminant transport along a particular pathway. Values of the waste containment effectiveness multiplier range from 0.1 to 1.0. A value of 0.1 signifies optimum state-of-the-art containment and is assigned for surface water pathways if the contaminants at the site are covered and surrounded by diversion structures that are in sound condition and adequate to contain any runoff, spills, or leaks from the waste. A value of 1.0 signifies little or no effective containment and is assigned if wastes or contaminants are exposed and no sound surface-runoff diversion system exists. Intermediate values of 0.5 and 0.8 signify intermediate levels of containment. In most cases where an observed release to surface water has occurred (i.e., score of 100 for item 1), a waste containment effectiveness multiplier of 1.0 is assigned. However, if measures have been taken to correct the condition that led to the observed release, it may be appropriate to assign a lower value for this multiplier.

Specific guidance on determining the waste containment effectiveness multiplier for surface water pathways should be obtained from Table 2. Note the basis for the selection of the multiplier in the "Comments" section of the score sheet.

Table 2. Waste containment effectiveness factors for surface water pathway [11]

Description	Score
Landfills, closed surface impoundments	
Landfill surface is properly graded; clay cap or other cover is in sound condition; any potential run-on is effectively diverted away from the landfill area; if landfill is in a floodplain, dikes or berms effectively prevent floodwater encroachment	0.1
Landfill is covered adequately and run-on diversion or flood protection structures are present if needed, but minor problems exist with either the cover or dike/diversion structures (e.g., dike is in poor repair or landfill surface is not adequately vegetated)	0.5
Waste is covered effectively (no waste exposure or leachate seeps), but needed run-on diversion or flood protection structures are absent; OR waste is covered (no waste exposure or leachate seeps) and any needed dike/diversion structures are present, but cover is in very poor condition [e.g., substantial subsidence has occurred that has not been repaired, extensive rill erosion has occurred, or clay/soil cover is less than 1 ft (0.3 m) thick]	0.8
Waste is exposed or leachate seeps have been reported	1.0
Spills, former fire protection training areas	
Contaminated material has apparently been removed completely, area is recontoured	0.1
Contaminants are present but appear to be effectively contained: contaminated area is covered with an impervious material not normally subject to cracking or covered with adequate thickness of clean soil and revegetated; any significant run-on to area is diverted; if area is in a floodplain, dikes/berms effectively prevent floodwater encroachment	0.5

Table 2. Waste containment effectiveness factors for surface water pathway [11] (continued)

Description	Score
Limited containment. Examples: Contaminated area is covered effectively but needed run-on diversion or flood protection is absent; OR contaminants may be exposed, but area is protected from significant run-on or flooding and surface runoff from area is collected and treated	0.8
Contaminants may be exposed; any runoff from the site would not be collected and treated	1.0
Surface impoundments (active)	
Sound dikes and adequate freeboard; if there is an effluent, it is treated and discharged in compliance with permits	0.1
Sound dikes, but inadequate freeboard; no evidence of past overflows or uncontrolled discharge	0.5
Dikes are not leaking nor are they in apparent danger of collapse, but there is some evidence of potential unsoundness (e.g., earthen dikes are eroded); no evidence of past overflows or uncontrolled discharge	0.8
Dikes are leaking or in danger of collapse, or there is evidence of past overflows or uncontrolled discharges	1.0
Fire protection training areas (active)	
Area is surrounded by sound concrete containment structures with adequate freeboard to prevent overflows; area is protected from floodwater encroachment; effluent from area is collected, pretreated in oil-water separator, and sent to wastewater treatment plant	0.1
Containment structures are sound but lack adequate freeboard; effluent is handled as above	0.5
Potential unsoundness in containment structures (e.g., constructed of earthen materials instead of concrete); effluent is handled as above	0.8

Table 2. Waste containment effectiveness factors for surface water pathway [11] (continued)

Description	Score
Surface effluent from area is not controlled, OR effluents are discharged directly from oil-water separator	1.0
Tanks	
Above ground tanks and piping are in sound condition and inspected regularly; tank area and associated transfer facilities are surrounded by a sound surface-water diversion system and bermed to prevent floodwater encroachment and to contain spills; no evidence of past leaks or spills	0.1
Above ground tanks and piping are in sound condition and tank area is bermed, but berms need repair or may be inadequate to contain spillage and subsequent rainfall	0.5
Above ground tanks and piping in sound condition but area is not bermed; OR tanks are sound and area is properly bermed, but there is evidence of past leaks or spills within the bermed area	0.8
Above ground tanks or piping are not in sound condition (e.g., they are visibly corroded or leaking); OR there is evidence of past leaks or spills in areas not protected by berms	1.0
Sites within enclosed structures	
Tanks, piping, containers, etc., are in sound condition and are inspected regularly; drainage from hazardous-material handling and storage areas is isolated from floor drain systems that connect to storm water drainage systems or sanitary sewers and is treated properly; any past spills or leaks are cleaned up completely	0.1
Tanks, piping, containers, etc., are in sound condition and are inspected regularly, and there is no evidence of past spills or leaks, but drainage from hazardous-material handling and storage areas is not effectively isolated from floor drain systems that connect to storm water drainage systems or sanitary sewers	0.5

Table 2. Waste containment effectiveness factors for surface water pathway [11] (continued)

Description	Score
Tanks, piping, containers, etc., are not in sound condition (e.g., visibly corroded or leaking) or there is evidence of past spills or leaks, but drainage from hazardous-material handling and storage areas is isolated from floor drain systems that connect to storm water drainage systems or sanitary sewers	0.8
Tanks, piping, containers, etc., are not in sound condition (e.g., visibly corroded or leaking) or there is evidence of past spills or leaks, and drainage from hazardous-material handling and storage areas is not effectively isolated from floor drain systems that connect to storm water drainage systems or sanitary sewers	1.0

2.2 GROUND WATER PATHWAYS

2.2.1 Observed Releases [13]

If contaminants from the rated site have already been detected in ground water, assign a score of 100 for this factor and proceed directly to the rating of waste containment effectiveness for ground water pathways (sect. 2.2.3). Otherwise, assign a score of zero and proceed to the scoring of pathway characteristics (sect. 2.2.2).

A finding that contaminants have been detected must be based on (1) at least one analytical determination in which contaminants were present in ground water at a level that represents a significant (in terms of demonstrating that contamination has occurred, not in terms of potential effects) increase above background and (2) an indication that the contaminants came from the rated site. If only one of several analyses indicated contamination and there is a good reason to suspect the validity of the analytical result, assign a score of zero and note the reason for this score in the "Comments" section of the score sheet.

2.2.2 Pathway Characteristics

Depth to seasonal high ground water [14] from the base of the waste or contaminated zone is measured vertically from the base of the deepest zone of observed contamination to the highest water table observed during the year. It is one indicator of the hydraulic potential for contaminants to reach the water table. Determinations of the depth of contamination and of the water table elevation will generally be based on subsurface investigations. Contaminant levels need not have been quantified at a particular depth in order to constitute "observed" contamination; qualitative evidence of contamination (such as a driller's log recording the presence of oil, solid waste, contaminants odors, etc.) should also be considered in determining the depth of contamination. For purposes of this evaluation, the highest water table should be considered, unless it is in a perched ground water zone that does not persist through the year and does not discharge to any surface water. If periodic monitoring of ground water levels has been done for a year or more, the highest water table elevation measured during the monitoring period will normally be used in this evaluation. However, if there is evidence that the monitoring period was drier than normal or that dewatering or pumping associated with nearby construction activities may have depressed the water table, such alternative indicators as the presence of mottled or gleyed soils should be used to determine the high water-table elevation.

Assign a score as follows:

Depth to ground water [14]	Score
>500 ft (>152 m)	0
50 to 500 ft (15 to 152 m)	1
10 to 50 ft (3 to 15 m)	2
<10 ft (<3 m)	3
Base of wastes is saturated	3

Note the basis for the score in the "Comments" section of the score sheet.

Permeability of the unsaturated zone [15] is one indicator of the hydraulic potential for contaminants to reach the water table. This factor should be evaluated on the basis of measurements of the saturated hydraulic conductivity of unsaturated-zone materials, if appropriate measurements are available. Scores should be assigned according to guidance given in Table 3. If appropriate measurements are not available, hydraulic conductivity should be estimated from the geologic origin and particle-size distribution of unsaturated-zone materials, using guidance in Table 3. If the unsaturated zone includes several layers with contrasting hydraulic conductivity, the harmonic mean of the hydraulic conductivities should be used in this evaluation. The formula for the harmonic mean is

$$1/H = 1/n(1/k1 + 1/k2 + \ldots + 1/kn),$$

where H is the harmonic mean,
n is the number of layers, and
k_a is the hydraulic conductivity of layer a.

Note the basis for the score in the "Comments" section of the score sheet.

Table 3. Guidance for scoring the permeability of the unsaturated zone [15]

Range of saturated hydraulic conductivity	Geologic materials	Score
$<10^{-7}$ cm/s	Clay, compact glacial till, shale; unfractured metamorphic and igneous rocks	0
10^{-5} to 10^{-7} cm/s	Silt, loess, silty clays, silt loams, clay loams; less permeable (i.e., well indurated, unfractured) limestone, dolomites, and sandstone; moderately permeable glacial till	1
10^{-3} to 10^{-5} cm/s	Fine sand and silty sand; sandy loams; loamy sands; moderately permeable limestone, dolomites, and sandstone (no karst); moderately fractured igneous and metamorphic rocks, coarse-grained glacial till	2
$>10^{-3}$ cm/s	Gravel, sand; highly fractured igneous and metamorphic rocks; permeable basalt and lavas; karst limestone and dolomite [a]	3

[a]Base score on geologic material only when hydraulic conductivity measurements are unavailable.

Source: Adapted from U.S. Environmental Protection Agency. 1982.

Infiltration potential [16] is a measure of the amount of water available to cause generation and infiltration of leachate, considering the net precipitation (evaluated as described in sect. 2.1.2) and the physical state of the waste. Assign a score based on the matrix in Table 4.

Table 4. Matrix for scoring infiltration potential [16]

	Net precipitation (in.)			
	<-10	-10 to 5	5 to 20	>20
Waste is a solid or an adherent to soil particles	0	1	2	3
Waste is a semisolid or sludge that may release free liquids upon consolidation or decomposition	2	2	3	3
Waste is a free liquid	3	3	3	3

The potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table [19] must be assessed qualitatively, considering the presence, character, and density of faults, fractures, faulty well casings, subsidence fissures, and similar features that might act as conduits for contaminant travel through the unsaturated zone. The assessment of "low potential" should be used when features that might form such conduits are present but are judged unlikely to do so. For example, a clay material with unoxidized fractures that appear to be closed should be assessed as having "low potential." The assessment of "high potential" should be used when features are present that seem likely to provide pathways for rapid contaminant transport through a sizeable fraction of the distance to the water table. For example, a "high potential" to "short-circuit" the pathway to the water table should be assigned when there is a well with a faulty casing in the contaminated area. A site with a high density of deep desiccation cracks should also be assessed as having "high potential." Assign a score as follows:

Potential for "short-circuit" [19]	Score
No evidence of discrete features that might "short-circuit" the pathway	0
Low potential	1
Moderate potential	2
High potential (including wastes below water table)	3

Note the basis for the score in the "Comments" section of the score sheet.

2.2.3 Waste Containment Effectiveness [21]

The waste containment effectiveness factor adjusts the pathways score to account for the effectiveness of engineered barriers or clean-up actions in reducing the potential for contaminant transport along a particular pathway. The waste containment effectiveness factor is a multiplier; values range from 0.1 to 1.0. A value of 0.1 signifies optimum state-of-the-art containment and is assigned for ground water pathways if the contaminants at the site are surrounded by essentially impermeable barriers and if the risk of barrier failure is minimized by back-up barriers and monitoring systems. A value of 1.0 signifies little or no effective containment. Intermediate values of 0.5 and 0.8 signify intermediate levels of containment.

Specific guidance on determining the waste containment effectiveness factor for ground water pathways should be obtained from Table 5. Note the basis for the selection of the waste containment effectiveness factor in the "Comments" section of the score sheet.

Table 5. Waste containment effectiveness factors for ground water pathways [21]

Description	Score
Sites where contamination has been observed in ground water	
In general, assign a score of 1.0 to signify uncontained contamination in the ground water, regardless of the apparent containment effectiveness of the waste facility. However, if some ground water clean-up has been done, a lower score may be contamination (e.g., storage tank area, landfill, or spill site), using the guidance below, and determine a score for existing ground water contamination, according to the following scale:	
Effective - Contaminated water is believed to have been removed completely	0.1
Moderately Effective - Contaminant enclave is physically contained (e.g., by subsurface cutoff walls keyed in to low-permeability layers)	0.5
Ineffective - Contaminant enclave has not been removed or effectively contained	1.0
The containment effectiveness factor is the higher of these two scores.	
Landfills, closed surface impoundments	
Liner is essentially impermeable, intact, and chemically compatible with waste; cover of low permeability and intact; leachate collection system above the liner; backup protection supplied by double liner with adequate leakage detection system or by ground water monitoring system that is adequate in type, number, and location of devices	0.1
Physical containment is adequate, but leakage detection and/or ground water monitoring system is inadequate	0.5
Minor deficiency in physical containment system (e.g., liner is moderately permeable, cover is defective, or no leachate collection)	0.8
Major deficiency(ies) in physical containment system (e.g., no liner, or liner is known to be perforated, or liner is probably chemically incompatible with the waste)	1.0

Table 5. Waste containment effectiveness factors for ground water pathways [21] (continued)

Description	Score
Active surface impoundments	
Liner essentially impermeable, intact, and chemically compatible with waste; backup protection is supplied by double liner or appropriate leakage detection system; ground water monitoring devices are adequate in type, number, and location	0.1
Physical containment system is sound, but leakage detection and/or ground water monitoring system is inadequate	0.5
Minor deficiency in physical containment (e.g., double liner is moderately permeable or in deteriorating condition)	0.8
Major deficiency(ies) in physical containment system (e.g., no liner, liner is known to be perforated, or liner is probably chemically incompatible with the waste)	1.0
Fire protection training areas (active)	
Area is lined with material that is essentially impermeable, intact, and chemically compatible with fuels; liner protected from heat and puncture by adequate thickness of buffer material (e.g., sand under gravel); backup protection is supplied by double liner or appropriate leakage detection or monitoring system; facility is regularly inspected for containment integrity	0.1
Containment system is sound but lacks complete backup protection (e.g., area has concrete surface with no double liner or leakage detection system, or there is no regular inspection), OR backup protection exists, but there are minor deficiencies in basic containment (e.g., liner is not protected from heat by a buffer layer)	0.5
Containment system is present but has potentially significant deficiencies (e.g., area has concrete surface without heat protection, double liner, or leakage detection system; or liner materials are now suspected to be chemically incompatible with some fuel constituents)	0.8

Table 5. Waste containment effectiveness factors for ground water pathways [21] (continued)

Description	Score
Major deficiencies in containment system (e.g., area is unlined, or liner is a synthetic membrane not protected from puncturing, or liner is perforated or shows other visible signs of deterioration)	1.0
Contaminants are present on ground surface or in soil (e.g., spills, former fire protection training areas)	
Contaminated materials appear to have been removed completely	0.1
Contaminated area is covered with impervious material that is expected to prevent further infiltration and leaching	0.5
No clean-up action or covering has been done	1.0
Above ground tanks	
Tanks and piping are in sound condition and are inspected regularly; tank area is lined to prevent infiltration to ground water and surrounded by berms	0.1
Tanks and piping are in sound condition, but tank area is not lined; OR tank area is bermed and lined to prevent infiltration to ground water, but tanks or piping show signs of deterioration or there is evidence of past leaks or spills within the lined and bermed area	0.8
Tanks or piping are leaking, OR tank area is not adequately lined and bermed and tanks or piping show signs of deterioration, OR there is evidence of past leaks or spills in areas not protected by liners and berms	1.0

Table 5. Waste containment effectiveness factors for ground water pathways [21] (concluded)

Description	Score
Underground tanks	
Tanks and piping are double-walled or installed above an impermeable liner; interior lining of tanks and piping is chemically compatible with contents; outer walls of tanks and piping are of noncorrosible material or cathodically protected from corrosion; leakage detection system exists	0.1
Tanks and piping are appropriately constructed, but no leakage detection system exists	0.5
Some deficiencies in tanks, piping, and/or leakage detection system (e.g., tank is double-walled and leakage detection system exists, but outer walls are not protected from corrosion; or tank is double-walled and leakage detection system exists, but interior lining of tank may not be chemically compatible with tank contents; or tank is single-walled and not installed above an impermeable liner, but tank material is noncorrosible and chemically compatible with tank contents and there is a leakage detection system)	0.8
Major deficiencies in physical containment (e.g., tank is single-walled, not installed above an impermeable liner, and there is no leakage detection system)	1.0
Sites within enclosed structures	
Score according to the type of site. For landfills and sites with contaminants present on the ground surface or in the soil, treat the roof of the structure as an impervious cover.	

2.3 AIR/SOIL PATHWAYS

2.3.1 Observed Releases [23,24]

If contaminants from the rated site have already been detected in ambient air [23] or volatile contaminants in soil [24] assign a score of 100 for these factors and proceed directly to the rating of waste containment effectiveness for the air/soil pathways (sect. 2.3.3). Otherwise, assign a score of zero and proceed to the scoring of pathway characteristics (sect. 2.3.2).

A finding that contaminants have been detected must be based on (1) at least one analytical determination in which contaminants were present in air or soil at a level that represents a significant (in terms of demonstrating that contamination has occurred, not in terms of potential effects) increase above background, and (2) an indication that contaminants came from the rated site. If only one of several analyses indicated contamination and there is reason to suspect the validity of the analytical result, assign a score of zero and note the reason for this score in the "Comments" section of the score sheet.

2.3.2 Pathway Characteristics

Average soil temperature [25] is an indicator for the volatilization rate of volatile compounds. It is defined as the annual average temperature of the site of interest (soil, landfill, or surface impoundment). If average soil temperature is available, use that value. Otherwise, assume that the average soil temperature equals the mean annual ambient temperature. Assign a score as follows:

Temperature, oC[25]	Score
< 0°	0
0° to 15°	1
15° to 25°	2
> 25°	3

Net precipitation [26] is an indicator of potential for reduction of the available pore space in the soil for diffusion of the volatile compounds. It is defined as average annual precipitation minus average lake evaporation (see item [3] above for how to calculate this). Where possible, data from local meteorological stations should be used for determining the annual net precipitation for scoring. When scoring for surface impoundments, enter a value of 0. Otherwise, assign a score as follows:

Net precipitation [26]	Score
< -10 in. (<-254mm)	0
- 10 to + 5 in. (-254 to +127 mm)	1

+ 6 to 20 in. (127 to 508 mm)	2
> 20 in. (> 508mm)	3

Wind velocity [27] is a factor for determining the gas-phase mass transfer of the volatile from the site surface to the air. Scoring should be based on the annual average wind speed at the site. This can be obtained from the site report or estimated from Figure 5. Assign a score as follows:

Wind velocity, mi/hr [27]	Score
0 - 5	0
6 - 10	1
11 - 15	2
15	3

Soil porosity [28] is an indicator of the available air space for diffusion of volatile compounds through the matrix. For closed landfills, porosity of the cap should be used for scoring. For open landfills and contaminated soil, the porosity of the soil should be used for scoring. For surface impoundments, enter a score of 0. Assign a score as follows:

Porosity* [28]	Score
< 0.10	0
0.10 to 0.25	1
0.26 to 0.40	2
> 0.40	3

* Porosity expressed as a decimal fraction, not a percentage

Days/year > 0.25 mm precipitation [29] is a measure of the number of wet days per year which will naturally control fugitive dust emissions. The number of days with at least 0.25 mm (0.01 inch) precipitation should be obtained from local climatic data. If the data are unavailable, refer to Figure 4. Assign a score of 0 for surface impoundments, otherwise assign a score as follows:

Days/year > 0.25 mm precipitation [29]	Score
>150	0
>100 and ≤150	1
>50 and ≤100	2
≤50	3

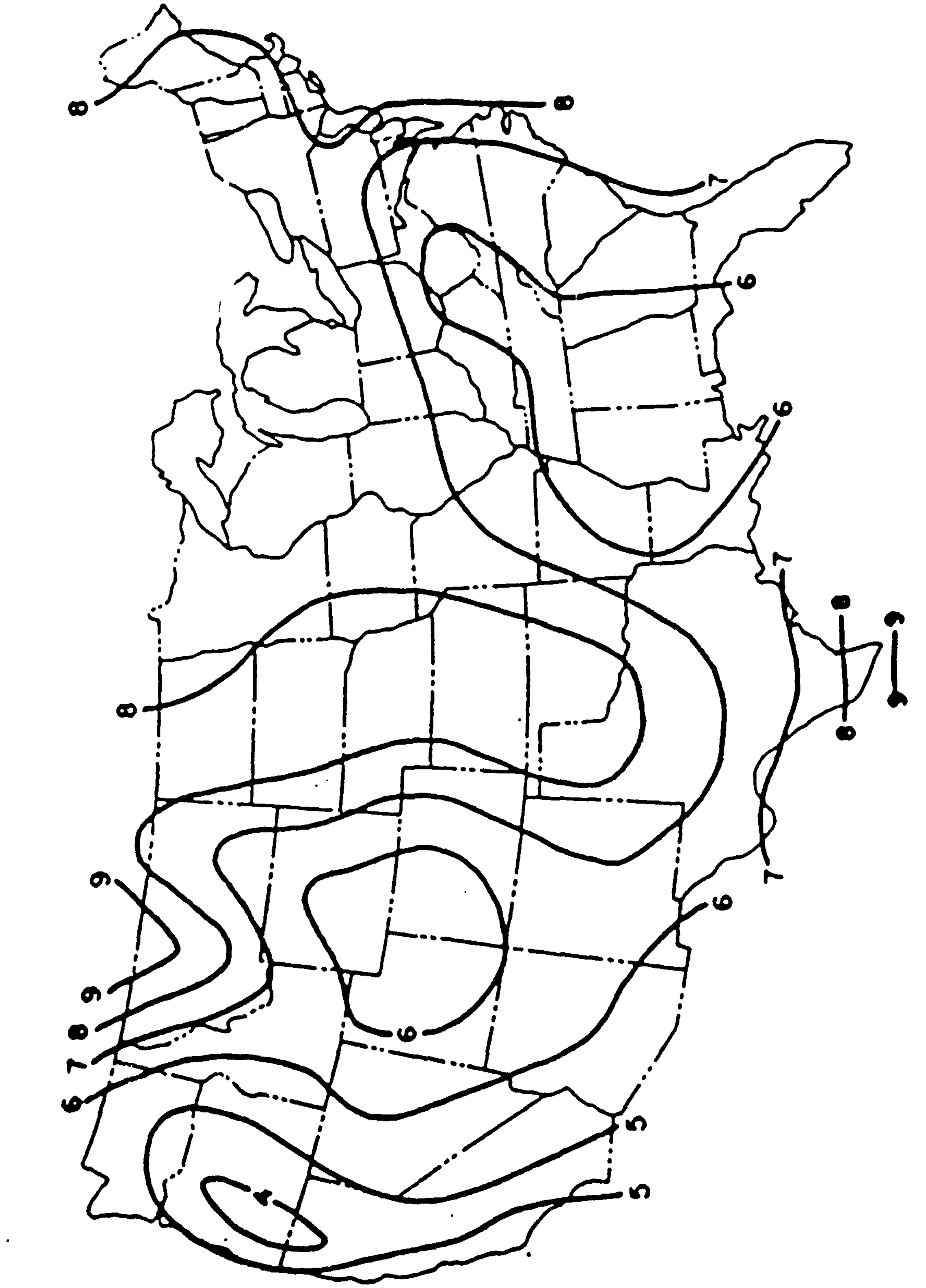

Figure 5. Mean annual wind speed averaged through the afternoon mixing layer. Speeds in meters/second. (From Fundamentals of Air Pollution, 2nd Edition, by A.C. Stern et. al., Academic Press, New York, 1984.)

Site activity [30] is a measure of activities on the site which may cause fugitive dust emissions. Activities which may cause these emissions include vehicle traffic on paved or unpaved surfaces, material excavation and movement, open landfill operations, and excavation/remedial activities of sites. Assign a score of 0 for surface impoundments, otherwise assign a score as follows:

Site Activity [30]	Score
No activity at site.	0
Activity at site limited to occasional vehicle traffic.	1
Moderate vehicle traffic and little or no excavation/material handling operations.	2
Heavy vehicle traffic daily or substantial activity including excavation and material handling.	3

Occasional vehicular traffic would include such things as intermittent security vehicle access and vehicular access for safety or environmental assessment personnel. Traffic would be less than 5 vehicle-trips per day. Moderate vehicular activity would include routine, though perhaps not daily, vehicular use of the site up to 15 vehicle-trips per day. Heavy vehicle traffic would involve more than 15 trips per day or fewer trips having extensive on-site vehicle movement. Generally, a vehicle-trip is assumed to be of short duration on-site perhaps with limited exposure to the entire site or simply as a means of access to adjacent property. If the vehicle-trips involve substantial on-site travel, use the next higher rating.

2.3.3 Waste Containment Effectiveness [34]

The waste containment effectiveness factor adjusts the pathways score to account for the effectiveness of engineered barriers or clean-up actions in reducing the potential for contaminant transport along a particular pathway. The waste containment effectiveness factor is a multiplier with values ranging from 0.1 to 1.0. A value of 0.1 signifies optimum state-of-the-art containment and is assigned for the site if VOC and fugitive dust emissions are properly controlled. A value of 1.0 signifies little or no effective containment of VOC or fugitive dust emissions. Waste containment effectiveness factors should be assigned as shown in Table 6:

Table 6. Waste Containment Effectiveness Factors for Air/Soil Pathways [34]

Description	Score
Closed (inactive) landfills	
Landfill covered with compacted clay cap which is in good condition; barometric pumping of landfill vented to VOC control system; landfill surface covered with vegetation to prevent fugitive dust emissions.	0.1
Landfill covered with compacted clay cap which has little or no damage; landfill vented to atmosphere; vegetation cover or dust suppression system used to prevent fugitive dust emissions.	0.5
Landfill covered with compacted clay cap; no vegetation or dust suppression system to control fugitive dust emissions.	0.8
Landfill lacks clay cap and soil cover.	1.0
Open (active) landfills	
Daily cover material applied; fugitive dust suppression system used during operations.	0.4
Daily cover material applied, little/no fugitive dust suppression used during operations.	0.8
No daily cover material applied, no fugitive dust suppression system used.	1.0
Contaminated soil	
Contaminated area completely covered by permanent structure such as a paved surface or building.	0.2
50% or more of contaminated area covered and fugitive dust suppression system used.	0.5
Contaminated area less than 50% covered or fugitive dust suppression system used.	0.8
No covering of contaminated area and no fugitive dust suppression system used.	1.0

Table 6. Waste Containment Effectiveness Factors for Air/Soil Pathways [34] (concluded)

Description	Score
Waste piles	
Waste pile located indoors in a closed structure with air pollution control on the building vent.	0.1
Outdoors but covered with physical barrier (e.g. tarp).	0.4
Uncovered outdoors, but treated with dust suppressant.	0.6
Open to atmosphere, no cover or dust suppression used.	1.0
Surface impoundments	
Impoundment enclosed with sealed structure and gases vented to control device; or, surface covered with floating synthetic membrane.	0.3
Deep, quiescent, non-agitated; or, shallow, quiescent, non-agitated with wind barrier.	0.5
Shallow, quiescent; non-agitated.	0.7
Agitated.	0.8
All other impoundments.	1.0

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3. CONTAMINANT HAZARD SCORING

The contaminant hazard component of the DPM methodology rates human health hazards and ecological hazards of identified contaminants on the basis of the effects benchmarks described in Barnthouse et al. and summarized in Appendix B. Six separate hazard scores are calculated: (1) human health hazards of surface water contaminants, (2) ecological hazards of surface water contaminants, (3) human health hazards of ground water contaminants, (4) ecological hazards of ground water contaminants, (5) human health hazards of air/soil contaminants, and (6) ecological hazards of air/soil contaminants.

Hazard scores are calculated differently, depending on whether environmental contamination has been detected. For media in which contamination has been detected, health hazard scoring is based on the concept of the acceptable daily intake (ADI). The observed concentration is first converted to a daily ingestion intake (in ug/day) and then divided by the appropriate benchmark from Appendix B (these are estimated ADIs). These quotients are then summed, and a hazard score is assigned based on the sum. This procedure is outlined in Figure 6. Ecological hazard scoring for media in which contamination has been detected is analogous. The observed concentrations are divided by the appropriate benchmark concentrations (Appendix B) and the quotients are summed. The hazard score is assigned based on these sums (Figure 7). Detailed procedures for scoring health and ecological hazards when contaminants have been detected are presented in Sect. 3.1.

For media in which contamination has not been detected, health hazard scores are assigned based on the ADIs and bioaccumulation factors of contaminants known to be present at the site being rated. Similarly, ecological hazard scores are assigned based on the benchmarks for toxicity to aquatic and terrestrial biota from Appendix B. Detailed procedures for scoring health and ecological hazards when contaminants have not been detected are presented in Sect. 3.2.

3.1 MEDIA WITH OBSERVED RELEASES

If contaminants are detected in the medium being scored, the observed contaminant concentrations are used to calculate the health hazard score. All contaminants detected above background levels are considered in scoring the site. Where multiple measurements have been made, use the highest value reported.

In general, if a substance was not detected or the concentration appears to be below the analytic detection limit, assume that the contaminant is absent and do not score it. However, for surface water in which a contaminant has been detected in bottom sediment but not in the water column, assume that the contaminant is also present in the water and use the analytic detection limit as the concentration present.

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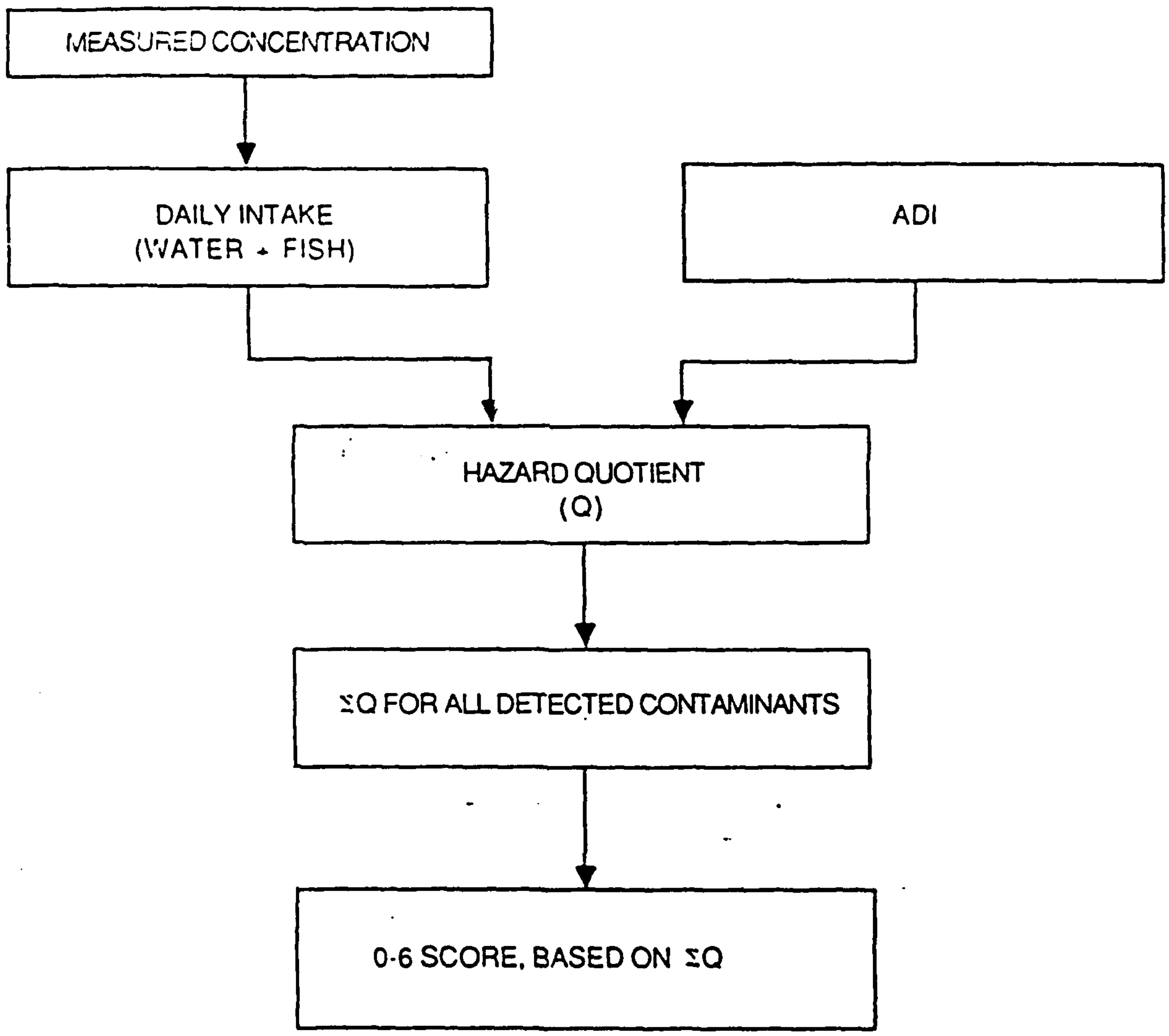

Fig. 5. Procedure for human health hazard scoring (media in which contamination has been detected).

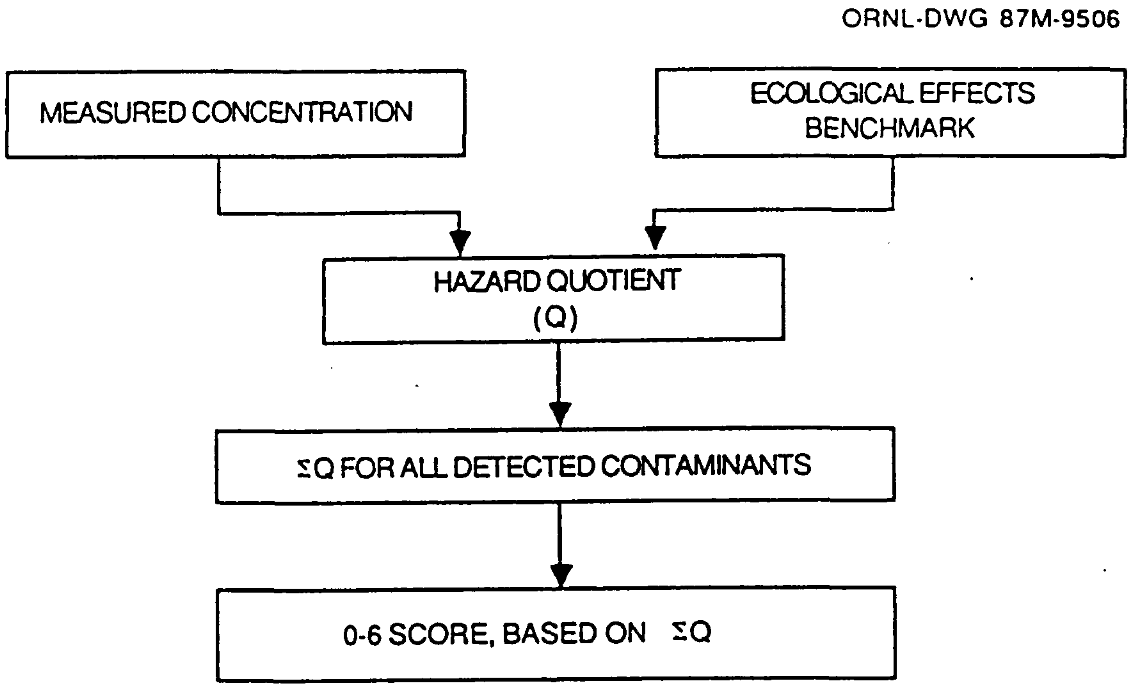

Fig. 6. Procedure for ecological hazard scoring (media in which contamination has been detected).

3.1.1 General Procedure

3.1.1.1 Contaminant Hazard Scoring - Surface and Ground Water Pathways

The first step in scoring the contaminant hazard for media with observed releases is filling out the Surface and Ground Water Hazard Worksheet (Appendix A). This worksheet provides a step-by-step procedure for quantitatively comparing the concentration of each contaminant with the benchmark concentrations associated with potential human health effects and ecological effects, and summing hazard quotients determined for each contaminant to obtain an estimate of the overall hazard associated with a particular site. Use of this worksheet will be greatly facilitated by converting the worksheet to a microcomputer spreadsheet.

In column 1, list the contaminants detected. In column 2 list, for each contaminant, the concentration detected, in units of micrograms per liter (ug/L) of the Surface and Ground Water Hazard Worksheet. Sometimes analytical reports report some or all concentrations in micrograms per milliliter (mg/mL), milligrams per liter (mg/L), or other units, so it is necessary to double-check that the concentration data entered on the hazard worksheet are in the correct units.

Consult Appendix B to obtain the health effects benchmark for each contaminant, and list this benchmark in column 3. For some heavy metals, Appendix B provides different benchmark values for different chemical forms. If the concentrations are broken out by chemical form, use the benchmark(s) for the form(s) identified. If the form of the metal is not reported, use the lowest benchmark for that metal. Similarly, Appendix B provides different benchmark values for different isomers of some organic chemicals. If specific isomers are not reported, use the lowest benchmark for the chemical reported. Consult Appendix B to obtain the aquatic and terrestrial ecological effects benchmarks for each contaminant and list these, respectively, in columns 4 and 5. Consult Appendix B to obtain the bioaccumulation factor for each contaminant, and list these values in column 6.

Although Appendix B includes approximately 200 chemicals and chemical mixtures, the user may find that a chemical that is not listed has been found at a site being scored. If the substance is not listed in these tables, then new benchmarks must be determined using the procedures described in Barnthouse et al. (1986). This should be done by individuals who are familiar with toxicology and environmental chemistry. These benchmarks are assumed to be independent of the pathway.

Now calculate the drinking water intake rate for each contaminant by multiplying the observed concentration (from column 2 of the worksheet) by the drinking water conversion factor (2 L/day). Enter the result in column 7. Calculate the intake rate for contaminated fish by multiplying the observed concentration (from column 2) by the bioaccumulation factor (from column 6) and by the fish consumption conversion factor (0.0065 kg/day). Enter the result in column 8. Enter the total intake for each contaminant (i.e., the sum of the values in columns 7 and 8) in column 9.

Calculate the health hazard quotient for each contaminant by dividing the total intake (column 9) by the health hazard benchmark (column 3). Enter the result in column 10. Calculate the aquatic ecological hazard quotient for each contaminant by dividing the observed concentration (column 2) by the aquatic hazard benchmark (column 4). Enter the result in column 11. Calculate the terrestrial ecological hazard quotient for each contaminant by dividing the observed concentration (column 2) by the terrestrial hazard benchmark (column 5). Enter the result in column 12. Sum the values in each of columns 10, 11, and 12 (assume missing values to be zeroes).

3.1.1.2 Contaminant Hazard Scoring -- Air Pathways

The contaminant hazard scoring for air pathways is scored similar to scoring for surface water and ground water pathways. For media in which contamination has been detected, health hazard scoring is based on the concept of the acceptable daily intake (ADI). The daily intake is based upon intake from inhalation of contaminant and ingestion of contaminated soil. The scores are determined by the same procedure as described for surface water and ground water pathways. Ecological hazard scoring for detected contaminants is also similar to that for surface and ground water pathways except that only terrestrial effects are considered.

For media in which contamination has not been detected, health hazard scores are assigned based on the ADIs and bioaccumulation factors of contaminants known to be present at the site being rated. Similarly, ecological hazard scores are assigned based on the benchmarks for toxicity to terrestrial biota. The procedures for determining the health and ecological hazard scores for contaminants that have not been detected is the same as the procedure used for surface water and ground water pathways.

The first step in scoring the contaminant hazard for sites where contaminants have been detected is to fill out the Air/Soil Hazard Worksheet. Contaminants are considered detected if: (1) contaminant has been detected from ambient air quality monitoring or (2) volatile contaminant has been detected in soil or surface impoundment. The Air/Soil Hazard Worksheet (Appendix A) follows the same similar procedures as for the Hazard Worksheet.

In column 1 of the Air/Soil Hazard Worksheet, list the contaminants detected. If the contaminant was detected by ambient air monitoring, list in column 2 for each contaminant, the concentration detected in units of g/m3. If the contaminant was detected at the site (in soil or surface impoundment), use the appropriate model to predict emission rate of the contaminant in g/s. Use the modeled emission rate with the air quality model to determine the air concentration in g/m3 and enter result in column 2.

In column 3 of the Air/Soil Hazard Worksheet, enter the soil concentration for each contaminant detected in mg/Kg soil. (This does not apply to surface impoundments).

Use the fugitive dust model for wind erosion to predict the emission rate of fugitive dust in g/s from the site being scored. Note that this model determines the total emission rate for fugitive dust, not for each constituent. Use the modeled emission rate with the air quality model to determine the air concentration of fugitive dust in g/m3 and enter the result in column 4.

Consult Appendix B to obtain the health effects and terrestrial effects benchmarks for each contaminant and list the benchmarks in columns 5 and 6 respectively. Determine benchmarks in the same manner as is done for the Hazardous Worksheet. Appendix D should be consulted for contaminant values needed to compute hazard scores.

Calculate the inhalation intake for each contaminant by summing the VOC air concentration (column 2) and the fugitive dust concentration (column 3) and multiplying the sum by an average inhalation rate of 20 m3/day and assuming 100% absorption of each contaminant. Note that the fugitive dust concentration is for total particulates. This must be converted to the contaminant concentration by assuming that the airborne particulates have the same contaminant concentration as the soil. Refer to the Air Hazard Worksheet for the exact calculation. Enter the result in column 7.

Calculate the soil ingestion rate for each contaminant by multiplying the soil concentration (column 3) by the soil ingestion rate for children (column 5) of 0.165 g/day. Refer to the Air Hazard Worksheet for the exact calculation. Enter the result in column 8. Enter the total daily intake for each contaminant in micrograms/day (sum of column 7 and column 8) in column 9.

Calculate the health hazard quotient for each contaminant by dividing the total intake (column 9) by the health hazard benchmark (column 5). Enter the result in column 10. Calculate the terrestrial hazard quotient for each contaminant by dividing the air concentration (VOC and from fugitive dust) by the terrestrial effects benchmark (column 6). Refer to the Air Hazard Worksheet for the exact calculation. Enter the result in column 11. Sum the values in both column 10 and column 11 (assume missing values to be zero) and calculate the sum. Calculate the human health hazard score by the same procedure as described for surface water and ground water pathways. Using the terrestrial hazard quotient, calculate the ecological hazard score by the same procedure as described for surface water and ground water pathways.

3.1.2 Human Health Hazard Scoring

Enter the sum of human health hazard quotients and the sum in the appropriate spaces [36 or 46] on the contaminant hazard score sheet. Assign a score [37 or 47] as follows:

Sum of human health hazard quotients [36 or 46]	Score [37 or 47]
<0.1	0
0.1 to 1	1
1 to 10	2
10 to 100	4
>100	6

Normalize the score to a 100-point scale (divide by 6 and multiply by 100), and enter the result in the contaminant hazard score sheet [38 or 48].

3.1.3 Ecological Hazard Scoring

The ecological hazard score for a given environmental medium is based on the larger of the sums of the aquatic or terrestrial hazard quotients (columns 11 and 12) for that medium. Enter the larger of the two sums of quotients and the sum in the appropriate spaces [39 or 49] on the contaminant hazard score sheet. Assign a score [40 or 50] as follows:

Sum of ecological hazard quotients [40 or 50]	Score
<0.01	0
0.01 to 0.1	1
0.1 to 1	2
1 to 10	3
10 to 100	4
100 to 1000	5
>1000	6

Normalize the score to a 100-point scale (divide by 6 and multiply by 100), and enter the result on the contaminant hazard score sheet [41 or 51].

3.2 MEDIA WITHOUT OBSERVED RELEASES

If contaminants have not yet been detected above background levels in the medium being scored, then contaminant hazard scores are calculated from health and ecological hazard benchmarks for contaminants known to be present at the site. A contaminant is known to be present at a site if (1) it has been detected in a chemical analysis of the waste, (2) it is a principal component of the materials that were placed or spilled on the site, or (3) it has been detected in a chemical analysis of site soils or waters at a level that represents a significant (in terms of demonstrating that contamination has occurred, not in terms of potential effects) increase above background. Scoring should not be based on any contaminant whose presence is merely suspected, inferred, or recollected by facility personnel; its presence must be confirmed. For example, at a site where a tank for storage of unused motor oil had ruptured, it would be acceptable to conclude that motor oil was present as a contaminant because motor oil had been placed in the tank and because a fluid that smelled like motor oil had been observed around the tank. It would not, however, be acceptable to conclude that lead (or some other contaminant) was also present unless lead had been detected at that site; neither the presence of lead at similar sites nor anecdotal information that lead-contaminated used oil had been delivered to the site confirms the presence of lead. In the case of a site where analytical data indicate contamination of ground water but it is not possible to determine whether surface water has been affected, contaminant hazard scores for surface water may be based on the contaminants that have been identified in ground water.

Contaminant hazard scoring for media in which contamination has not been confirmed is based on the toxicity benchmarks and bioaccumulation factors for contaminants known to be present at the site. Tables 7 and 8 contain guidance for assigning human health hazard and ecological hazard scores based on toxicological benchmarks and bioaccumulation factors. For convenience, scores for all contaminants for which toxicity benchmarks and bioaccumulation factors have been developed are listed in Appendix B.

To score a pathway in which contaminants have not been detected, list all contaminants known to be present at the site. For each contaminant, consult Appendix B to obtain human health and ecological hazard scores. Attach the list of contaminants to the score sheet, and enter the highest scores and the name(s) of the associated contaminant(s) in the appropriate spaces [42 and 44 or 52 and 54] on the score sheet. Calculate the final health hazard score by normalizing the raw score to 100 [43 and 45 or 53 and 55].

Table 7. Assignment of human health hazard scores [42 or 52] based on values of the health effects benchmark and bioaccumulation factor

Health effect benchmark	Bioaccumulation factor			
	<10	10-99	100-999	>1,000
≥ 2,000	0	0	1	2
200 to 2,000	0	1	2	3
2 to 200	1	2	3	4
0.02 to 2	2	3	4	5
0.0002 to 0.02	4	5	6	7
< 0.0002	6	7	8	9

Table 8. Assignment of hazard scores for effects on aquatic and terrestrial biota [44 or 54] based on toxicity benchmarks

	Toxicity benchmark				
	>1,000,000	10,000-999,999	100-9,999	1-99	<1
Score	0	1	2	4	6

Intentionally left blank

4. RECEPTORS SCORING

The receptors portion of the DPM methodology rates the potential for humans and ecological resources to be exposed to contaminants from a waste site, in case such contaminants are present in surface waters, ground water, air and/or soil. Six separate types of receptors are considered: (1) human health receptors of surface water contaminants, (2) ecological receptors of surface water contaminants, (3) human health receptors of ground water contaminants, (4) ecological receptors of ground water contaminants, (5) human health receptors of air/soil contaminants, and (6) ecological receptors of air/soil contaminants.

4.1 SURFACE WATER RECEPTORS

4.1.1 Human Health Receptors

The population that obtains drinking water from potentially affected downslope surface waters downstream [66] from the point of potential contaminant entry is one indicator of the potential for humans to ingest contaminants in surface waters.

For purposes of DPM scoring, limit consideration to those surface-water sources that are within 5 miles (8.0 km) stream distance downstream of either (1) documented surface water or sediment contamination attributable to the site being scored or (2) a point of potential contaminant entry that is within 5 miles (8.0 km) linear map distance of the contaminant source. Points of potential contaminant entry may be identified by tracing from the site to the nearest surface water bodies along likely downslope flow paths for overland flow from the site and the likely route for any flood waters that periodically encroach upon the site. To determine whether a surface-water source is within 5 miles (8.0 km) of a point of potential contaminant entry, measure the downstream distance in stream miles (or stream kilometers) from the point of potential contaminant entry to the water-supply intake. For the purpose of scoring this item, "downstream" means (1) the prevailing flow direction of an undammed river or stream that is unaffected by tidal or backwater influences, (2) any direction in a lake or impoundment, or (3) any direction in a stream reach or estuary in which flow direction is frequently altered by tidal effects, backwater effects from downstream dams, or other hydraulic influences.

Evaluate this item on the basis of the population served at the time of scoring. If there has recently been a significant change in the number of users of a water-supply intake or if such a change is projected (e.g., a municipal supply system may be adding new water-supply intakes to supply increased demand, or a particular intake may have been abandoned due to contamination), record this information on the "Comments" portion, but do not consider past or future users when scoring this item. In determining population, count residents as well as others who regularly use the water, such as base employees and other workers. If a water-supply system regularly obtains water from several different intakes (e.g., both a surface-water intake and a well), prorate the total population served by the system according to the proportion of the total water supply that normally comes from the intake(s) of interest. If the fraction of the water supply from each of several intakes is highly variable or cannot be determined, score this item on the basis of the total population served by the water-supply system. If the population served by a water-supply system is not known, estimate it by counting residences in the service area (e.g., from a topographic map or aerial photo) and assuming 3.8 persons per dwelling unit. Note the estimated population in the "Comments" section of the score sheet and assign a score as follows:

Population served [66]

Miles from Entry	Population Size: 0	1-50	51-1000	1001-10,000	>10,000
0 to 3	0	1	2	3	3
>3 to 4	0	0	1	2	3
>4 to 5	0	0	0	1	2

Water use of the nearest surface water body(ies) [67] within the path of contaminant travel is evaluated to identify uses of potentially affected surface waters that could lead to human ingestion of any contaminants. Note the rationale for scoring in the "Comments" section and assign a score as follows:

Surface water use [67]	Score
No uses; OR no surface water within 1 mile (1.6 km) downslope	0
Non-food-chain agriculture, recreation other than fishing, industrial uses other than food processing	1
Shellfish propagation, fishing, irrigation of food-chain crops, water supply for meat or dairy livestock, water supply for food processing	2
Drinking water source	3

Population within 1500 ft (458 m) of the site [68] is one indicator of the potential for humans to come into contact with contaminated waters through routes other than ingestion. Count both residential and daytime populations of on- and off-base facilities. If the residential population in a given area is not known, estimate it by counting residences (e.g., from a topographic map or aerial photo) and assuming 3.8 persons per dwelling unit. Assign a score as follows:

Population within 1500 ft (458 m) of the site [68]

Distance in Feet	Population Size: 0	1-25	26-100	101-1000	>1,000
<1,000	0	1	2	3	3
1,000 to 1,249	0	0	1	2	3
1,250 to 1,500	0	0	0	1	3

The distance to the nearest installation boundary [69] is an indicator of the potential for humans to come into contact with contaminated waters through routes other than ingestion. Measure the shortest linear distance from the edge of the contaminated area to the installation boundary. Assign a score as follows:

Distance to installation boundary [69]	Score
>2 miles (>3.2 km)	0
1 to 2 miles (1.6 to 3.2 km)	1
3000 ft to 1 mile (0.9 to 1.6 km)	2
<3000 ft (<0.9 km)	3

Land use and zoning within 2 miles (3.2 km) [70] of the site are indicators of the potential for humans to come into contact with contaminated waters through routes other than ingestion. In the case of mixed land uses or zoning for a more sensitive use than is currently present (e.g., an agricultural area with residential zoning), assign the highest applicable score. Assign a score as follows:

Land use and/or Zoning	Land use and/or zoning [70]			
Distance to site (mi)	Completely Remote	Agricultural	Commercial/ Industrial	Residential
0 to 0.9	0	1	2	3
1.0 to 1.4	0	0	1	2
1.5 to 2.0	0	0	0	1

4.1.2 Ecological Receptors

Importance/sensitivity of biota/habitats in potentially affected downslope surface waters nearest the site [73] is one measure of the potential exposure of ecological receptors. Both aquatic habitats (e.g., streams, lakes, the ocean, and arms of the ocean) and terrestrial habitats associated with water (e.g., wetlands, floodplains) are considered in evaluating this factor.

In scoring, consider the surface water body(ies) most likely to receive surface-transported contaminants and any associated wetlands or riparian areas. For streams, limit consideration to stream reaches and riparian areas within 4 miles (2.7 km) downstream or within 1.5 miles (2.4 km) in any other direction from either (1) documented surface water contamination that is attributable to the site being scored or (2) a probable point of contaminant entry. For the purpose of scoring this item, "downstream" means (1) the prevailing flow direction of an undammed river or stream that is unaffected by tidal or backwater influences, (2) any direction in a lake or impoundment, or (3) any direction in a stream reach or estuary in which flow direction is frequently altered by tidal effects, backwater effects from downstream dams, or other hydraulic influences.

In scoring this item, "critical environments" are defined to include (1) lands or waters specifically recognized or managed by federal, state, or local government agencies or private organizations as rare, unique, unusually sensitive, or important natural resources (including designated critical habitat for endangered species, wilderness areas, nature preserves, or wildlife sanctuaries, but not parks established for historic preservation or recreation); and (2) habitat utilized by any federally designated endangered species on a permanent or seasonal basis. "Wetlands" are defined as lands (i.e., not streams, lakes, or other aquatic habitats) which are at least periodically saturated or flooded with water and in which "water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface" (Cowardin et al. 1979). "Ephemeral" surface waters are those bodies of water in which water is present only during and immediately after precipitation or snowmelt vents. In "intermittent" surface water bodies, water ceases to be present occasionally or seasonally. Assign the highest applicable score from the following:

Character of biota/habitats [73]	Score	
	3 miles down-stream or 1 mile in any direction	3-4 mile down-stream or 1-1.5 miles in any direction
Surface water ephemeral or absent; no wetlands; no perennially or seasonally flooded or irrigated vegetation; no critical environments	0	0
Permanent or intermittent stream, wetlands <3 acres (<1.2 ha), spring, or coastal marine environment that is not managed for fishing or hunting and that does not constitute a critical environment; small area [<100 acres (<40 ha)] of irrigated vegetation	1	0
Lake or reservoir; wetlands >3 acres (>1.2 ha); regionally important spawning, nursery, nesting, or feeding grounds; permanent or intermittent stream, tidal estuary, or other aquatic environment that is managed for fish or wildlife; extensive areas [>100 acres (>40 ha)] of irrigated vegetation	2	1
Critical environment	3	2

Presence of "critical environments" within 1.5 miles (2.4 km) of the site in any direction [74] is an indicator of the potential for harm to unusually sensitive ecological receptors. "Critical environments" are defined to include (1) lands or waters specifically recognized or managed by federal, state, or local government agencies or private organizations as rare, unique, unusually sensitive, or important natural resources (including designated critical habitat for endangered species, wilderness areas, nature preserves, or wildlife sanctuaries, but not parks established for historic preservation or recreation); and (2) habitat utilized by any federally designated endangered species on a permanent or seasonal basis. Assign a score as follows:

Presence of critical environments [74]	Score within 1 mile	Score within 1-1.5 miles
Critical environments absent	0	0
Critical environments present	3	1

4.2 GROUND WATER RECEPTORS

4.2.1 Human Health Receptors

Estimated mean ground water travel time from current waste location to nearest downgradient water-supply well(s) [77] is a measure of the potential for contaminants to reach sites of ground water use. In scoring this item, consider all wells currently used to supply water for human consumption, food processing, or food-chain agriculture or aquaculture. Do not consider (1) wells that are used exclusively for water-quality monitoring or remediation of ground water contamination, (2) wells that formerly supplied water for human consumption or other listed uses but whose use for these purposes has been curtailed, or (3) wells that supply water for industrial processes unrelated to food production. Include any wells that normally supply water for human consumption or other listed uses but whose use has been suspended temporarily (e.g., for maintenance or because they are used to augment other water sources during periods of high seasonal demand).

"Downgradient" is defined to mean a 90- to 120-degree arc containing at its center the best estimate of the ground water flow direction. Travel time should be calculated to the screened or open interval of the well. The "nearest" downgradient well is defined as the downgradient well with the shortest travel time from the waste site, which is not necessarily the downgradient well with the shortest linear distance to the waste site; for example, a shallow well drawing water from the uppermost aquifer might have a shorter travel time than a deep well in a confined aquifer, even though the deep well is nearer the waste site than the shallow well. It may be necessary to determine travel time to more than one well in order to identify the well with the shortest travel time. If no survey of well locations is available, assume that any residence (identified from maps or air photos) not in the service area of a public water-supply system has a private well. If the depth of the open interval of a particular well is unknown, assume that the well draws water from the aquifer with the shortest possible travel time from the waste site.

Mean ground water travel time is calculated from the estimated hydraulic conductivity of the affected aquifer (k), the hydraulic gradient in the affected aquifer (i), the flow distance to the well (d), and the effective porosity of the affected aquifer (n), using the following equation:

$$\text{travel time} = dn/ki$$

For the purpose of this calculation, k, the hydraulic conductivity of aquifer, should be entered in velocity units (e.g., ft/year or m/day). In the absence of site specific estimates, k may be estimated from soil and aquifer descriptions as follows: (go to Table 9).

Table 9. Values of hydraulic conductivity (in m/d) for use in estimating ground water travel time [77, 78, and 85]

Unconsolidated sediments*

	Meters/Day
Clay soils (surface)	0.01-0.2
Deep clay beds	10^{-4}-10^{-2}
Fine sand	1-5
Medium sand	5-20
Coarse sand	20-100
Gravel	100-1000

*Use values at the high ends of the range for clean, well-sorted sediments, such as uniform sands. Use values at the low ends of the ranges for dirty, poorly sorted sediments. For materials that are intermediates between categories, use judgment in interpolating. Mixtures should generally be assigned values at the low ends of ranges for the coarser components.

Consolidated rocks**

	Meters/Day
Sandstone	0.001-1
Carbonate rock with significant solution porosity	1-100
Carbonate rock with secondary porosity, solution openings not significant	0.01-1

Shale	.0001
Granite, basalt, other igneous or metamorphic rocks	0.001-10

**Use values at the high ends of the ranges for rocks that are extensively fractured, poorly cemented, weathered, or have extensive development of solution openings. Use low ends of the ranges for relatively tight units. Based on Bouwer (1978), Freeze and Cherry (1979).

Effective porosity, n, should be entered as a decimal fraction (e.g., 0.10, not 10%). In the absence of site-specific estimates, estimate n from Table 10:

Table 10. Values of effective porosity for use in estimating ground water travel time. [77, 78, and 85]

Unconsolidated deposits*	
Gravel or sand	0.20
Silt	0.15
Clay or silty clay, no fractures present	0.01
Fractured clay	0.001
Rocks	
Sandstone	0.05-0.15[a]
Carbonate rock	0.001-0.05[a]
Shale	0.001
Crystalline rock (e.g., granite)	0.0001-0.01[a]

*Use values at the high end of the range for poorly cemented or poorly indurated rocks without well-developed secondary porosity; i.e., most sandstones, "young" carbonates, weathered crystalline rocks. Use values at the low end of the range for well-cemented or well-indurated rocks with low primary porosity and significant secondary porosity; i.e., some sandstones, most carbonates, most crystalline rocks.

[a]Based on Davis and DeWiest (1966), Freeze and Cherry (1979), USEPA (1986), Walton (1970).

The hydraulic gradient should be reported as a dimensionless fraction (e.g., ft/ft or m/m) and should be estimated from field observations as the difference in hydraulic potential between two points along the flow path, divided by the distance between those points. Where no data are available on hydraulic gradients, a gradient typical of the hydrogeologic setting should be used (e.g., the gradient reported in a regional ground water report), and the basis for the estimate should be documented in the "Comments". Where the direction of ground water flow is highly uncertain or indeterminate, estimate travel time to the nearest well in any direction, using an estimate of the hydraulic gradient that would be typical for the hydrogeologic setting. For calculation purposes, it may be appropriate to break the flow path into several segments (e.g., a vertical segment through a confining layer and a horizontal segment in the underlying aquifer).

Record the assumptions made in the calculation and the calculation results in the "Comments" and assign a score as follows:

Ground water travel time [77]	Score
>100 years	0
20 to 100 years	1
5 to 20 years	2
<5 years	3

Estimated mean ground water travel time to any downgradient surface water body that supplies water for human consumption, domestic use, food processing, or food-chain agriculture or aquaculture within 3 miles (4.8 km) downstream from the site of potential discharge of contaminated ground water [78] is a measure of the potential for contaminants to reach human receptors via natural discharge of contaminated ground water. "Downgradient" is defined to mean a 90- to 120-degree arc containing at its center the best estimate of the ground water flow direction (as determined from the available data). Travel time determinations should be made only to surface water bodies that are judged to be ground water discharge sites; ephemeral streams, perched lakes, and other surface waters that do not appear to receive ground water discharge should not be considered in evaluating this factor. Consider only surface waters with water-supply intakes or in situ water uses within 3 miles (4.8 km) downstream from the estimated site of potential discharge of contaminated ground water. For the purpose of scoring this item, "downstream" means (1) the prevailing flow direction of an undammed river or stream that is unaffected by tidal or backwater influences, (2) any direction in a lake or impoundment, or (3) any direction in a stream reach or estuary in which flow direction is frequently altered by tidal effects, backwater effects from downstream dams, or other hydraulic influences. Also for purposes of scoring, "aquaculture" includes commercial harvesting of fish and shellfish.

Mean ground water travel time is calculated from the estimated hydraulic conductivity of the affected aquifer (k), the hydraulic gradient in the affected aquifer (i), the flow distance to the surface water (d), and the effective porosity of the affected aquifer (n), using the following equation:

$$\text{travel time} = dn/ki$$

For the purpose of this calculation, k, the hydraulic conductivity of aquifer, should be entered in velocity units (e.g., ft/year or m/day). In the absence of site-specific estimates, k and n may be estimated from soil and aquifer descriptions, using typical values from Table 9. Effective porosity, n, should be entered as a decimal fraction (e.g., 0.10, not 10%). In the absence of site specific estimates, estimate n according to Table 10.

The hydraulic gradient should be reported as a dimensionless fraction (e.g., ft/ft or m/m) and is defined as the difference between the ground water elevation at the contaminated site and the surface water elevation at the discharge site, divided by the map distance between those points. If the direction of ground water flow is uncertain (e.g., for a contaminated site located on a ground water divide) calculate the shortest travel time to a ground water discharge site in any direction. For calculation purposes, it may be appropriate to break the flow path into several segments (e.g., a vertical segment through a confining layer and a horizontal segment in the underlying aquifer).

Record the assumptions made in the calculation and the calculation results in the "Comments" section of the score sheet, and assign a score as follows:

Ground water travel time [78]	Score — Downstream Distance from Entry	
	< 3.0 miles	> 3.0 miles
>100 years	0	0
20 to 100 years	1	0
5 to 20 years	2	1
<5 years	3	2

The ground water use of the uppermost aquifer [79] is evaluated to identify uses of the most susceptible ground waters that could lead to human ingestion of any contaminants. Consider only aquifers that are believed to be present below the site, but consider all uses of these aquifers in the vicinity or region. The "uppermost aquifer" is defined as the ground water-bearing unit nearest the ground surface. If a perched water table is present and there is another aquifer within 200 ft (61 m) of the ground surface, in scoring this item consider both the perched aquifer and the aquifer next closest to the ground surface. In evaluating the availability of alternative water supplies, do not consider bottled water as an alternative. Record the basis for scoring in the "Comments":

Ground water use of uppermost aquifer [79]	Score
No aquifer directly below the site; OR uppermost aquifer is not used and other water sources are available	0
Commercial, industrial, or irrigation; other water sources available to aquifer users (e.g., from a municipal supply that already serves or could be extended to serve the area, or from a deeper aquifer that could be tapped by drilling deeper wells)	1
Drinking water; another source of water is readily available to aquifer users (e.g., from a municipal supply that includes the well owners' homes in its service area)	2
Drinking water source, no alternative water supply readily available; OR commercial, industrial or irrigation, no other water source available	3

The population potentially at risk from ground water contamination [80] may have several components. The people with the highest risk of exposure to ground water-borne contaminants are those who obtain water supplies for human consumption from ground water sources (i.e., wells or springs) that lie directly on the most likely paths of contaminant travel. Another class of ground water users who are at somewhat less risk consists of people who obtain water supplies for human consumption from ground water sources that are downgradient from the contaminant source, but are not on the most likely paths of contaminant travel. One example of this class of users is a person who obtains water from a confined aquifer that has a lower hydraulic head than a contaminated shallow aquifer, but that is not believed to be on the most likely path of contaminant travel because most water in the shallow aquifer discharges to nearby streams. A third component of the population potentially at risk from contaminated ground water consists of people who obtain water from surface water sources downstream from potential ground water discharge points that lie directly on the most likely paths of contaminant travel. Because of greater dilution in surface waters, these people are at somewhat less risk than are people who use ground water drawn from along the most likely paths of contaminant travel. A final group included in the population potentially at risk consists of people who obtain water supplies from nearby ground water sources that are not believed to be downgradient from the contaminant source. These ground water sources have a small finite risk of contamination due to their proximity to a contaminant source and the possibility that ground water flow directions could have been delineated incorrectly or could change in the future.

Scoring of this item is based on the size of the total population potentially at risk and the degree of vulnerability of the component of that population that is at highest risk of exposure to ground water-borne contaminants. The first step in scoring is to determine the number of people who belong to each component of the population potentially at risk. An accounting of the number of people assigned to each component should be included in the "Comments".

In determining which class a particular ground water source (i.e., well or spring) belongs to, the "most likely paths of contaminant travel" are defined as the principal paths along which ground water flows away from the contaminated site. These can usually be inferred from hydrogeologic reports. In humid settings, the most likely travel path in a shallow aquifer might be a subhorizontal flow path toward a nearby stream, and flow to a deep downgradient aquifer separated from the shallow aquifer by a confining layer might be regarded as relatively unlikely. In some climatic and geologic settings, however, surface-water discharge sites are rare, and the most likely path of contaminant travel is often toward deep wells in a regional water-supply aquifer. If different flow patterns are believed to prevail during different seasons of the year or in particularly wet or dry periods, any flow path that prevails at any time should be regarded as a most likely travel path. Directions of ground water flow are often imprecise, so the most likely flow path should be assumed to encompass all areas within a 90- to 120-degree arc containing at its center the best estimate of the ground water flow direction. If there is uncertainty as to whether a particular water source lies on a most likely travel path (because the direction of ground water flow or identity of most likely travel paths is uncertain), assume that it lies on the most likely travel path.

In determining the number of people who obtain water supplies for human consumption from a particular water source, count residential water users as well as others who regularly use the water, such as Air Force Base employees and other workers. The water source(s) should be located in the area of interest (e.g., along a most likely travel path), but the water users need not be. If some people obtain water from more than one source (e.g., an Air Force Base worker who drinks water from a deep base well that is downgradient but not on a "most likely travel path" while at work and from a shallow well on a "most likely travel path" while at home), they should be counted only once, in the most vulnerable water-user class to which they belong. If the population served by a water-supply system is not known, estimate it by counting residences in the service area (e.g., from a topographic map or aerial photo) and assuming 3.8 persons per dwelling unit. If a water-supply system regularly obtains water from several different sources (e.g., from both a well and a surface source), prorate the total population served by the system according to the proportion of the total water supply that normally comes from each source. (For example, if 50% of the annual supply of a municipal system comes from wells that are downgradient from a contaminant source, consider that 50% of the people served by that municipal system obtain water from those wells.) If the fraction of the water supply from each source is highly variable or cannot be determined, assign scores on the basis of the total population served. If no survey of private well locations is available, assume that any residence (identified from maps or aerial photos) not in a public water-supply service area has a private well that serves 3.8 persons. To score a water-supply source that serves as a supplemental supply (e.g., a spring from which members of the public regularly fill jugs), estimate the number of people who use the source and the fraction of their annual ingestion of water that comes from the source (these estimates are likely to be quite speculative), and prorate accordingly. For example, if a spring is regularly visited by all of the 200 households in a community (representing about 760 people) and users typically obtain about 25% of their drinking and cooking water from the spring, score the spring as having (0.25 x 760) users, or 190 users.

The most vulnerable component of the population at risk consists of people who obtain water supplies for human consumption from ground water sources (i.e., wells or springs) that lie directly on the most likely paths of contaminant travel within 3 miles (4.8 km) linear map distance from the site. Procedures for identifying the most likely paths of contaminant travel and for determining the number of people served by a given well or spring are discussed above.

The second component of the population at risk consists of people who obtain water supplies for human consumption from ground water sources (i.e., wells or springs) that are downgradient from the contaminated area within 3 miles (4.8 km) linear map distance from the perimeter of the contaminated area, but are not on the most likely paths of contaminant travel. One example of this class of users is a person who obtains water from a confined aquifer that has a lower hydraulic head than a contaminated shallow aquifer, but that is not believed to be on the most likely path of contaminant travel because most water in the shallow aquifer discharges to nearby streams.

"Downgradient" is defined to mean a 90- to 120-degree arc containing at its center the best estimate of the ground water flow direction. Where the direction of ground water flow is highly uncertain or indeterminate, treat all ground water sources in any direction as "downgradient." If some individuals who obtain water from a ground water source that is downgradient but not on a most likely travel path also use ground water from sources in the most vulnerable category and were included in the first component of the population at risk, do not include them in this component of the population at risk.

The third component of the population potentially at risk from contaminated ground water, people who obtain water from surface water sources downstream from potential ground water discharge points that lie directly on the most likely paths of contaminant travel, is scored as being equally as vulnerable as the second component. For purposes of DPM scoring, consideration is limited to those surface-water sources that are within 3 miles (4.8 km) stream distance of a ground water discharge point that is within 3 miles (4.8 km) linear map distance of the contaminant source. To determine whether a surface-water source is within 3 miles (4.8 km) of a ground water discharge point, measure the distance in stream miles (or stream kilometers) from the estimated point of contaminant discharge to the water-supply intake. Procedures for identifying the most likely paths of contaminant travel and for determining the number of people served by a given well or spring are discussed above. For the purpose of scoring this item, "downstream" means (1) the prevailing flow direction of an undammed river or stream that is unaffected by tidal or backwater influences, (2) any direction in a lake or impoundment, or (3) any direction in a stream reach or estuary in which flow direction is frequently altered by tidal effects, backwater effects from downstream dams, or other hydraulic influences. If some individuals who obtain water from a surface-water source downstream from a potential groundwater discharge point on a most likely travel path also use ground water from downgradient sources and were included in the first or second component of the population potentially at risk, do not include them in this component.

The last component of the population potentially at risk comprises people who obtain water supplies from ground water sources (i.e., wells or springs) that are located within 3 miles (4.8 km) linear map distance from the site and are not believed to be downgradient from the contaminant source. Procedures for identifying the most likely paths of contaminant travel and for determining the number of people served by a given well or spring are discussed above, as is the definition of "downgradient." If some individuals who obtain water from ground water sources that are not believed to be downgradient from the contaminant source also use water from a more vulnerable source and were included in one of the other components of the population potentially at risk, do not include them in this component.

Sum the numbers of people in each population component to obtain the total population potentially at risk, and assign a score from the matrix in Table 11.

Table 11. Scoring matrix for the population potentially at risk from ground water contamination [80]

Most vulnerable class of water users	Total population potentially at risk			
	0	1-50	51-1000	>1000
Users of ground water along most likely travel paths	0	12	24	36
Other downgradient ground water users OR users of surface water downstream from discharge points	0	9	18	27
Users of ground water not downgradient	0	3	6	9

Population within 1000 ft (305 m) [81] is one indicator of the potential for humans to come into contact with contaminated waters through routes other than ingestion. Consider populations within 1000 ft (305 m) of the site or the contaminant enclave, and count both the residential and daytime populations of on- and off-base facilities. If the residential population in a given area is not known, estimate it by counting residences (e.g., from a topographic map or aerial photo) and assuming 3.8 persons per dwelling unit.

Population within 1000 ft (305 m) [81]

Distance in Feet	Population Within Distance of Site				
	0	1-25	26-1000	101-1,000	> 1,000
<1,000	0	1	2	3	3
1,000 to 1,249	0	0	1	2	3
1,250 to 1,500	0	0	0	1	2

The distance to the nearest installation boundary [82] is an indicator of the potential for humans to come into contact with contaminated waters through routes other than ingestion. Measure the shortest linear distance from the edge of the contaminated area (including any subsurface contaminant enclave) to the installation boundary.

Distance to installation boundary [82]	Score
>2 miles (>3.2 km)	0
1 to 2 miles (1.6 to 3.2 km)	1
3000 ft to 1 mile (0.9 to 1.6 km)	2
<3000 ft (<0.9 km)	3

4.2.2 Ecological Receptors

Estimated mean ground water travel time from current waste location to any downgradient habitat or natural area [85] is a measure of the potential for contaminants to reach ecological receptors via natural discharge of contaminated ground water. "Downgradient" is defined to mean a 90- to 120-degree arc containing at its center the best estimate of the ground water flow direction. Travel time determinations should be made only to habitats or natural areas that are judged to be ground water discharge sites; ephemeral streams, perched lakes or wetlands, and other areas that do not appear to receive ground water discharge should not be considered in evaluating this factor.

Mean ground water travel time is calculated from the estimated hydraulic conductivity of the affected aquifer (k), the hydraulic gradient in the affected aquifer (i), the flow distance to the natural area (d), and the effective porosity of the affected aquifer (n), using the following equation:

$$\text{travel time} = dn/ki$$

For the purpose of this calculation, k, hydraulic conductivity of the aquifer, should be reported in velocity units (e.g., ft/year or m/day). In the absence of site-specific estimates, k may be estimated from soil and aquifer descriptions, using typical values from Table 9. Effective porosity, n, should be entered as a decimal fraction (e.g., 0.10, not 10%). In the absence of site-specific estimates, estimate n according to Table 10.

The hydraulic gradient should be reported as a dimensionless fraction (e.g., ft/ft or m/m), and is defined as the difference between the ground water elevation at the contaminated site and the surface water elevation at the discharge site, divided by the flow distance between those points. If the direction of ground water flow is uncertain (e.g.; for a contaminated site located on a hydrologic divide), calculate the shortest travel time to a ground water discharge site in any direction. For calculation purposes, it may be appropriate to break the flow path into several segments (e.g., a vertical segment through a confining layer and a horizontal segment in the underlying aquifer).

Record the assumptions made in the calculation and the calculation results in the "Comments" section of the score sheet, and assign a score as follows:

Ground water travel time [85]	Score
>100 years	0
20 to 100 years	1
5 to 20 years	2
<5 years	3

Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected discharge points [86] is one measure of the potential exposure of ecological receptors. Both aquatic habitats (e.g.; streams, lakes, the ocean, and arms of the ocean) and terrestrial habitats associated with water (e.g., wetlands, floodplains) are considered in evaluating this factor.

In scoring, consider the surface water body(ies) most likely to receive ground water discharge and any associated wetlands or riparian areas. For streams, limit consideration to stream reaches and riparian areas in the vicinity of the suspected point of ground water discharge and within 3 miles (4.8 km) downstream from that point. For the purpose of scoring this item, "downstream" means (1) the prevailing flow direction of an undammed river or stream that is unaffected by tidal or backwater influences, (2) any direction in a lake or impoundment, or (3) any direction in a stream reach or estuary in which flow direction is frequently altered by tidal effects, backwater effects from downstream dams, or other hydraulic influences. "Critical environments" are defined to include (1) lands or waters specifically recognized or managed by federal, state, or local government agencies or private organizations as rare, unique, unusually sensitive, or important natural resources (including designated critical habitat for endangered species, wilderness areas, nature preserves, or wildlife sanctuaries, but not parks established for historic preservation or recreation); and (2) habitat utilized by any federally designated endangered species on a permanent or seasonal basis. "Wetlands" are defined as lands (i.e., not streams, lakes, or other aquatic habitats) which are at least periodically saturated or flooded with water and in which "water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface"

(Cowardin et al. 1979). "Ephemeral" surface waters are those bodies of water in which water is present only during and immediately after precipitation or snowmelt events. In "intermittent" surface water bodies, water ceases to be present occasionally or seasonally.

Assign the highest applicable score from the following:

Character of biota/habitats [86]	Score: 3 miles downstream or 1 mile in any direction	Score: 3-4 miles downstream or 1-1.5 miles in any direction
Surface water ephemeral or absent; no wetlands; no perennially or seasonally flooded vegetation or vegetation irrigated with ground water; no critical environments; OR no ground water discharges within 3 miles (4.8 km) from the site in a downgradient direction	0	0
Permanent or intermittent stream, wetlands <3 acres (<1.2 ha), spring, or coastal marine environment that is not managed for fishing or hunting and that does not constitute a critical environment; small area [<100 acres (<40 ha)] of vegetation irrigated with ground water	1	0
Lake or reservoir; wetland >3 acres (>1.2 ha); regionally important spawning, nursery, nesting, or feeding grounds; permanent or intermittent stream, tidal estuary, or other aquatic environment that is managed for fish or wildlife; extensive areas [>100 acres (>40 ha)] of vegetation irrigated with ground water	2	1
Critical environment	3	2

Presence of "critical environments" within 1.5 miles (2.4 km) of the site in any direction [87] is an indicator of the potential for harm to unusually sensitive ecological receptors. "Critical environments" are defined to include (1) lands or waters specifically recognized or managed by federal, state, or local government agencies or private organizations as rare, unique, unusually sensitive, or important natural resources (including designated critical habitat for endangered species, wilderness areas, nature preserves, or wildlife sanctuaries, but not parks established for historic preservation or recreation); and (2) habitat utilized by any federally designated endangered species on a permanent or seasonal basis. Assign a score as follows:

Presence of critical environments [87]	Score	
	within 1 mile	within 1-1.5 miles
Critical environments absent	0	0
Critical environments present	3	1

4.3 AIR/SOIL RECEPTORS

4.3.1 Human Health Receptors Scoring

Population within a 4 mile radius [90] is an indicator of the population which may be harmed from hazardous substances released to the air. The distance is measured from the location of the site, not the facility boundary. The population to be counted includes persons residing within the four-mile radius as well as transients such as workers in factories, offices, restaurants, motels, or base employees. It excludes travelers passing through the area. Select the highest value for this as follows:

Population [90]	0-4 miles	0-1 mile	0-1/2 mile	0-1/4 mile
0	0	0	0	0
1 to 100	9	12	15	18
101 to 1000	12	15	18	21
1001 to 3000	15	18	21	24
3001 to 10,000	18	21	24	27
More than 10,000	21	24	27	30

Land use [91] indicates the nature and level of human activity in the vicinity of the site. Assign the highest applicable score as follows:

Score =	0	1	2	3
Distance to Commercial-Industrial	> 1 mile	1/2 to 1 mile	1/4 to 1/2 mile	< 1/4 mile
Distance to National/ State Parks, Forests, Wildlife Reserves, and Residential Areas.	> 2 miles	1 to 2 miles	1/4 to 1 mile	< 1/4 mile

The distance to nearest installation boundary [92] is an indicator of the potential for humans to come into contact with contaminants other than from inhalation. Measure the shortest linear distance from the edge of the contaminated area to the installation boundary. Assign a score as follows:

Distance to installation boundary [92]	Score
> 2 miles (> 3.2 km)	0
1 to 2 miles (1.6 to 3.2 km)	1
3000 ft to 1 mile (0.9 to 1.6 km)	2
< 3000 ft (< 0.9 km)	3

4.3.2 Ecological Receptors Scoring

Distance to sensitive environment [95] is an indicator of the likelihood that a region that contains important biological resources or that a fragile natural setting would suffer serious damage if hazardous substances were to be released from the facility. Assign scores as follows:

Score =	0	1	2	3
Distance to Wetlands (5 acres minimum)				
Coastal	>2 miles	1 to 2 miles	1/2 to 1 mile	<1/2 mile
Fresh water	>1 mile	1/4 to 1 mile	100 ft to 1/4 mi	<100 ft
Distance to Critical Habitat (of endangered species)	>1 mile	1/2 to 1 mile	1/4 to 1/2 mile	<1/4 mile

Presence of "critical environments" within 1.5 miles (2.4 km) of the site in any direction [96] is an indicator of the potential for harm to the unusually sensitive ecological receptors. "Critical environments" are defined to include lands or waters specifically recognized or managed by federal, state, or local government agencies or private organizations as rare, unique, unusually sensitive, or important natural resources (including designated critical habitat for endangered species, wilderness areas, nature preserves, or wildlife sanctuaries, but not parks established for historic preservation or recreation); and habitat utilized by any federally designated endangered species on a permanent or seasonal basis. Assign scores as follows:

Presence of critical environments [96]	Score	Within 1-1.5 miles
Critical environments absent	0	0
Critical environments present	3	1

5. SCORE AGGREGATION

In DPM, the pathway, hazard, and receptor subscores for each pathway-receptor combination are multiplied together, and the products of subscores are normalized to a 100-point scale to obtain individual risk scores for each pathway-receptor combination. These scores are then aggregated using a weighted root-mean-square algorithm to obtain the final site score:

$$S_f = \frac{[5(S_{s,h})^2 + (S_{s,e})^2 + 5(S_{g,h})^2 + (S_{g,e})^2 + 5(S_{a,h})^2\ (S_{a,e})^2]^{1/2}}{4.24}$$

where S_f = overall site score and $S_{s,h}$, $S_{s,e}$, $S_{g,h}$, $S_{g,e}$, $S_{a,h}$ and $S_{a,e}$ = scores for the surface water-human health, surface water-ecological, ground-water-human health, ground water-ecological, air/soil-human health, and air/soil-ecological pathway-receptor combinations. Score items 99 through 104; provide a step-by-step guide to the score aggregation procedure.

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APPENDIX A

BLANK SCORE SHEETS AND EXMAPLE APPLICATIONS

A.1 BLANK SCORE SHEETS

Site identification:

SURFACE WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
Observed Releases				
1. Have contaminants been detected in surface water? If yes, assign score of 100 and proceed to item 10. If no, assign score of 0 and proceed to item 2.	0 100	1	-------	100
Pathway Characteristics				
2. Distance to nearest surface water	0 1 2 3	4	-------	12
3. Net precipitation	0 1 2 3	1	-------	3
4. Surface erosion potential (Table 1)	0 1 2 3	4	-------	12
5. Rainfall intensity	0 1 2 3	4	-------	12
6. Surface permeability	0 1 2 3	3	-------	9
7. Sum of items 2 through 6			-------	48
8. Normalized score (multiply item 7 x 100/48)			-------	
9. Flooding potential	0 1 2 3	8	-------	24
10. Adjusted pathways score If item 1 is 100, enter 100. If item 1 is 0, enter sum of items 8 and 9. If sum exceeds 100, enter 100.			-------	
11. Waste containment effectiveness factor (Table 2).			-------	
12. Final score for surface water pathways (multiply item 10 x item 11).			-------	

COMMENTS ON SURFACE PATHWAYS

Site identification:

GROUND WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
Observed Releases				
13. Have contaminants been detected in ground water? If yes, assign score of 100 and proceed to item 20. If no, assign score of 0 and proceed to item 14.	0 100	1	-------	100
Pathway Characteristics				
14. Distance to seasonal high ground-water from base of waste or contaminated zone	0 1 2 3	9	-------	27
15. Permeability of the unsaturated zone (Table 3)	0 1 2 3	5	-------	15
16. Infiltration potential (Table 4)	0 1 2 3	5	-------	15
17. Sum of items 14 through 16			-------	57
18. Normalized score (multiply item 17 x 100/57)			-------	
19. Potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table	0 1 2 3	5	-------	15
20. Adjusted pathways score. If item 13 is 100, enter 100. If item 13 is 0, enter sum of items 18 and 19. If sum exceeds 100, enter 100.			-------	
21. Waste containment effectiveness factor (Table 5)			-------	
22. Final score for ground water pathways (multiply item 20 x item 21)			-------	

COMMENTS ON GROUND WATER PATHWAYS

Site identification:

AIR/SOILS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
Observed Releases				
23. Have contaminants been detected in ambient air above background levels? If yes, assign score of 100 and proceed to item 31. If no, assign score of 0 and proceed to item 24.	0 100	1	-------	100
Pathway Characteristics				
24. Have volatile contaminants been detected in site (surface impoundment, landfill, soil)? If yes, assign a score of 3 and proceed to item 25. If no, assign a score of 0 and proceed to item 33.	0 3	12	-------	36
25. Average temperature.	0 1 2 3	2	-------	6
26. Net precipitation.	0 1 2 3	2	-------	6
27. Wind velocity.	0 1 2 3	2	-------	6
28. Soil porosity.	0 1 2 3	2	-------	6
29. Days per year > 0.25 mm precipitation.	0 1 2 3	2	-------	6
30. Site Activity.	0 1 2 3	2	-------	6
31. Sum of items 24 through 30.			-------	72
32. Normalize score (multiply item 31 x 100/72).			-------	
33. Adjusted pathways score. If item 23 is 100, enter 100. If item 1 is 0 and item 24 is 0, enter 0. If item 24 is not 0, enter value from item 32.			-------	
34. Waste containment effectiveness factor.			-------	
35. Final score for air/soil pathway (multiply item 33 x item 34).			-------	

COMMENTS ON AIR PATHWAYS

Site identification:

CONTAMINANT HAZARD -- SURFACE WATER

If contaminants have been detected in surface water (score of 100 in item 1), complete items 36 through 41. If contaminants have not been detected (score of 0 in item 1, complete items 42 through 45. Attach Air Surface/Ground Water Worksheet or list of contaminants as appropriate.

	Score (circle one)	Result
36. Sum of human health hazard quotients (from column 10 of Hazard Worksheet.		-----
37. Human health hazard score.	0 1 2 4 6	-----
38. Normalized human health hazard score (multiply item 24 x 100/6).		-----
39. Sum of ecological hazard quotients (enter the larger of the sume of column 11 or 12 of Hazard Worksheet).		-----
40. Ecological hazard score.	0 1 2 3 4 5 6	-----
41. Normalized ecological hazard score (multiply item 40 x 100/6).		-----

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42. Maximum human health hazard index.	0 1 2 3 4 5 6 7 8 9	Contaminant: ________
43. Normalized human health hazard score (multiply item 42 x 100/9).		--------
44. Maximum ecological hazard index.	0 1 2 4 6	Contaminant: ________
45. Normalized ecological hazard score (multiply item 44 x 100/6).		--------

Site identification:

CONTAMINANT HAZARD -- GROUND WATER

If contaminants have been detected in ground water (score of 100 in item 13), complete items 46 through 51. If contaminants have not been detected (score of 0 in item 13), complete items 52 through 55. Attach Surface/Ground water Hazard Worksheet or list of contaminants as appropriate.

	Score (circle one)	Result
46. Sum of human health hazard quotients (from column 10 of Hazard Worksheet		-----
47. Human health hazard score	0 1 2 4 6	-----
48. Normalized human health hazard score (multiply item 47 x 100/6)		-----
49. Sum of ecological hazard quotients (enter the larger of the sum of column 11 or 12 of Hazard Worksheet)		-----
50. Ecological hazard score	0 1 2 3 4 5 6	-----
51. Normalized ecological hazard score (multiply item 50 x 100/6).		-----

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52. Maximum human health hazard index.	0 1 2 3 4 5 6 7 8 9	Contaminant: ______
53. Normalized human health hazard score (multiply item 52 x 100/9).		-------
54. Maximum ecological hazard index.	0 1 2 4 6	Contaminant: ______
55. Normalized ecological hazard score (multiply item 54 x 100/6).		-------

Site identification:

CONTAMINANT HAZARD -- AIR/SOIL

If contaminants have been detected in ambient air (score of 100 in item 23) or if volatile contaminants have been detected in site (score of 3 in item 24 complete items 56 through 61. If contaminants have not been detected (score of 0 in item 23 and item 24, complete items 62 through 65. Attach Air Hazard Worksheet or list of contaminants as appropriate.

	Score (circle one)	Result
56. Sum of human health hazard quotients (from column 6 of Hazard Worksheet		-------
57. Human health hazard score	0 1 2 4 6	
58. Normalized human health hazard score (multiply item 57 x 100/6)		-------
59. Sum of ecological hazard quotients (enter the sum of column 11 of Air Hazard Worksheet		-------
60. Ecological hazard score.	0 1 2 3 4 5 6	
61. Normalized ecological hazard score (multiply item 60 x 100/6).		-------

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	Score (circle one)	Result
62. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant:________________
63. Normalized human health hazard score (multiply item 62 x 100/9)		-----
64. Maximum ecological hazard index	0 1 2 4 6	Contaminant:________________
65. Normalized ecological hazard score (multiply item 64 x 100/6)		-----

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Site identification:

HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
66. Population that obtains drinking water from potentially affected surface water body(ies) downstream	0 1 2 3	3	-------	9
67. Water use of nearest surface water body(ies)	0 1 2 3	3	-------	9
68. Population within 1500 ft (458 m) of the site	0 1 2 3	1	-------	3
69. Distance to the nearest installation boundary column 7 of Hazard Worksheet)	0 1 2 3	1	-------	3
70. Land use and/or zoning within 2 miles (3.2 km) of the site	0 1 2 3	1	-------	3
71. Sum of items 66 through 70			-------	27
72. Final score for human health receptors on surface water pathways (multiply item 71 x 100/27)			-------	

ECOLOGICAL RECEPTORS -- SURFACE WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
73. Importance/sensitivity of biota/habitats in potentially affected surface water bodies nearest the site	0 1 2 3	5	-------	15
74. Presence of "critical environments" within 1 mile (1.6 km) of the site	0 3	1	-------	3
75. Sum of items 73 and 74			-------	
76. Final score for ecological receptors on surface water pathways (multiply item 75 X 100/18)			-------	18

COMMENTS ON SURFACE WATER RECEPTORS

Site identification:

HUMAN HEALTH RECEPTORS -- GROUND WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
77. Estimated mean ground water travel time from waste location to nearest downgradient water supply well(s)	0 1 2 3	9	-------	27
78. Estimated mean ground water travel time from current waste location to any downgradient surface water body that supplies water for domestic use or for food chain agriculture	0 1 2 3	5	-------	15
79. Grounwater use of the uppermost aquifer.	0 1 2 3	4	-------	12
80. Population potentially at risk from ground water contamination	0 3 6 9 12 18 24 27 36	1	-------	36
81. Population within 1000 ft . (305 m) of the site	0 1 2 3	1	-------	3
82. Distance to the nearest installation boundary	0 1 2 3	1	-------	3
83. Sum of items 77 through 82			-------	96
84. Final score for human health receptors on ground water pathways (multiply item 83 x 100/96)			-------	

ECOLOGICAL RECEPTORS -- GROUND WATER PATHWAYS

85. Estimated mean ground water travel time from waste location to any downgradient habitat or natural area	0 1 2 3	3	-------	9
86. Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected ground water discharge points	0 1 2 3	3	-------	9

COMMENTS ON SURFACE WATER RECEPTORS

Site identification:

ECOLOGICAL RECEPTORS -- GROUND WATER PATHWAYS (concluded)

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
87. Presence of "critical environments" within 1.5 miles (2.4 km) of the site	0 1 3	1	-------	3
88. Sum of items 85 through 87.			-------	21
89. Final score for ecological receptors on ground water pathways (multiply item 88 x 100/21)			-------	

COMMENTS ON GROUND WATER RECEPTORS (attach additional pages if needed)

Site identification:

HUMAN HEALTH RECEPTORS -- AIR/SOIL PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
90. Population within 4 miles radius	0 9 12 15 18 21 24 27 30	1	-------	30
91. Land use	0 1 2 3	2	-------	6
92. Distance to nearest installation boundary	0 1 2 3	1	-------	3
93. Sum of items 90 through 92			-------	39
94. Final score for human health receptors on air pathways (multiply item 93 x 100/39)			-------	

ECOLOGICAL RECEPTORS -- AIR/SOIL PATHWAYS

95. Distance to sensitive environment	0 1 2 3	2	-------	6
96. Presence of "critical environments" within 1.5 mile (2.4 km) of the site	0 3	1	-------	3
97. Sum of items 95 and 96			-------	9
98. Final score for ecological receptors on air pathways (multiply item 97 x 100/9)			-------	

COMMENTS ON AIR/SOIL PATHWAY RECEPTORS

Site identification: ______________________________

SCORING SUMMARY SHEET

		Pathways score		Contaminant hazard score		Receptors score		Overall score
99.	Surface water/human health scores	(______ item 12	x	______ item 38/43	x	______ item 72	) /10,000=	______
100.	Surface water/ecological scores	(______ item 12	x	______ item 41/45	x	______ item 76	) /10,000=	______
101.	Ground water/human health scores	(______ item 22	x	______ item 48/53	x	______ item 84	) /10,000=	______
102.	Ground water/ecological scores	(______ item 22	x	______ item 51/55	x	______ item 89	) /10,000=	______
103.	Air/Soil human score	(______ item 35	x	______ item 58/63	x	______ item 94	) /10,000=	______
104.	Air/Soil ecological scores	(______ item 35	x	______ item 61/65	x	______ item 98	) /10,000=	______

OVERALL SITE SCORE:

105. $[(\underset{\text{item 99}}{\_\_\_\_})^2 \times 5 + (\underset{\text{item 100}}{\_\_\_\_})^2 + (\underset{\text{item 101}}{\_\_\_\_})^2 \times 5 + (\underset{\text{item 102}}{\_\_\_\_})^2 + (\underset{\text{item 103}}{\_\_\_\_})^2 \times 5 + (\underset{\text{item 104}}{\_\_\_\_})^2]^{1/2} =$ ______

106. Overall site score = $\underset{\text{item 105}}{\_\_\_\_\_\_}$ / 4.24 = _____

SURFACE/GROUND WATER HAZARD WORKSHEET

1 Contaminant name	2 Concentration (G/L)	3 Health effects benchmark (g/day)	4 Aquatic effects benchmark (g/L)	5 Terrestrial effects benchmark (g/L)	6 Bioaccumulation factor (L/kg)	7 Health Hazard Index	8 Aquatic Hazard Index	9 Terrestrial Hazard Index
Toluene		24.0	175,000	-	83	1	2	1
Benzene		30.0	5,300	-	32	2	2	2
						Sum=	Sum=	Sum =

a (col 2) x (2 L/day)
b (col 2) x (col 6) x (0.0065 kg/day)
c (col 7) + (col 8)
d (col 9) / (col 3)
e (col 2) / (col 4)
f (col 2) / (col 5)

AIR/SOIL HAZARD WORKSHEET

1 Contaminant name	2 VOC air concentration (g/m3)	3 Soil concentration (mg/Kg) (25 ft)	4 Fugitive dust air concentration (g/m^3)	5 Health effects benchmark (ug/day)	6 Terrestrial effects benchmark (ug/L)	7 Inhalation intake (ug/day)[a]	8 Soil Ingestion intake (ug/day)[b]	9 Total intake (ug/day)[c]	10 Health hazard quotient[d]	11 Terrestrial hazard quotient[e]
			.0103							
benzene	7.7×10^{-6}	29.8		30		160.56	4.91	165.47	5.52	
ethylbenzene	5.7×10^{-6}	105		16		135.20	17.32	152.53	9.53	
toluene	8.8×10^{-6}	55.8		2200		187.09	9.207	196.30	0.09	
xylenes	3.3×10^{-6}	298		24		127.41	49.17	176.58	7.36	
									22.59	
									Sum=	

[a] [(col 2) + (col 4)x(col 3)x(10^{-6} Kg/mg)] x (20 m^3/day) x (10^6 ug/g)
[b] (col 3) x (10^{-6} Kg/mg) x (0.165 g/day) x (10^6 ug/g)
[c] (col 7) + (col 8)
[d] (col 9) / (col 5)
[e] {[(col 2) + (col 4)x(col 3)x(10^{-6} Kg/mg)] x (1000)} / (col 6)

A.2 EXAMPLES OF APPLICATION OF DPM

This section includes filled-in score sheets for a representative site. These are provided to assist the user in identifying information that should be documented on the score sheets and in interpreting the guidance in the text. In addition, Sect. A.2.2 includes detailed discussions of scoring examples for some of the more complex scoring items in DPM. These discussions are provided to display the reasoning involved in scoring these items.

A.2.1 Filled in Score Sheets for A Representative Site

Filled-in score sheets are provided for former waste disposal site at the Castle Air Force Base in Merced, CA. The site has both known and potential soil and ground water contamination resulting from past-routine operations and disposal practices. The particular site chosen was an underground fuel leak. Therefore this site is probably typical of the sites that would be encountered in routine application of DPM.

Scoring of this site was based on information in IRP Phase I and Phase II reports. Most of this information was collected between 1980 and 1987, so conditions at the site may have changed and the information on the attached score sheets should not be regarded as definitive.

In the example, subscores are reported to 1 or 2 decimal places. Subscore values should be carried to several decimal places, however, when calculating overall scores.

Site identification:

SURFACE WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
Observed Releases				
1. Have contaminants been detected in surface water? If yes, assign score of 100 and proceed to item 10. If no, assign score of 0 and proceed to item 2.	0 100	1	0	100
Pathway Characteristics				
2. Distance to nearest surface water	0 1 2 3	4	4	12
3. Net precipitation	0 1 2 3	1	0	3
4. Surface erosion potential (Table 1)	0 1 2 3	4	4	12
5. Rainfall intensity	0 1 2 3	4	8	12
6. Surface permeability	0 1 2 3	3	6	9
7. Sum of items 2 through 6			22	48
8. Normalized score (multiply item 7 x 100/48)			45.83	
9. Flooding potential	0 1 2 3	8	0	24
10. Adjusted pathways score If item 1 is 100, enter 100. If item 1 is 0, enter sum of items 8 and 9. If sum exceeds 100, enter 100.			45.83	
11. Waste containment effectiveness factor (Table 2).			0.8	
12. Final score for surface water pathways (multiply item 10 x item 11).			36.67	

COMMENTS ON SURFACE PATHWAYS

1. There have been no releases to surface water.
2. Assumes nearest water is Canal Creek (5250 ft.).
3. Net preciptation of -47.8.
4. Slight
5. 2.8
9. Felt site was not in a floodplain.
11. Spill. Assuming ground surrounding leak is containment.

Site identification:

GROUND WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
Observed Releases				
13. Have contaminants been detected in ground water? If yes, assign score of 100 and proceed to item 20. If no, assign score of 0 and proceed to item 14.	0 100	1	0	100
Pathway Characteristics				
14. Distance to seasonal high groundwater from base of waste or contaminated zone	0 1 2 3	9	27	27
15. Permeability of the unsaturated zone (Table 3)	0 1 2 3	5	5	15
16. Infiltration potential (Table 4)	0 1 2 3	5	0	15
17. Sum of items 14 through 16			32	57
18. Normalized score (multiply item 17 x 100/57)			56.14	
19. Potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table	0 1 2 3	5	0	15
20. Adjusted pathways score. If item 13 is 100, enter 100. If item 13 is 0, enter sum of items 18 and 19. If sum exceeds 100, enter 100.			56.14	
21. Waste containment effectiveness factor (Table 5)			1	
22. Final score for ground water pathways (multiply item 20 x item 21)			56.14	

COMMENTS ON GROUND WATER PATHWAYS

14. Seasonal high ground water is 37.3 feet below surface.
15. Calculated harmonic mean of the saturated zone.
21. Site has overgrown. No effort to correct problem.

Site identification:

AIR/SOILS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
Observed Releases				
23. Have contaminants been detected in ambient air above background levels? If yes, assign score of 100 and proceed to item 31. If no, assign score of 0 and proceed to item 24.	0 100	1	0	100
Pathway Characteristics				
24. Have volatile contaminants been detected in site (surface impoundment, landfill, soil)? If yes, assign a score of 3 and proceed to item 25. If no, assign a score of 0 and proceed to item 33.	0 3	12	36	36
25. Average temperature.	0 1 2 3	2	4	6
26. Net precipitation.	0 1 2 3	2	6	6
27. Wind velocity.	0 1 2 3	2	2	6
28. Soil porosity.	0 1 2 3	2	0	6
29. Days per year > 0.25 mm precipitation.	0 1 2 3	2	4	6
30. Site Activity.	0 1 2 3	2	6	6
31. Sum of items 24 through 30.			58	72
32. Normalize score (multiply item 31 x 100/72).			80.56	
33. Adjusted pathways score. If item 23 is 100, enter 100. If item 23 is 0 and item 24 is 0, enter 0. If item 24 is not 0, enter value from item 32.			80.56	
34. Waste containment effectiveness factor.			1.0	
35. Final score for air/soil pathway (multiply item 33 x item 34).			80.56	

Pathway Characteristics (Continued)

COMMENTS ON AIR PATHWAYS

23. There have been no releases to ground water p4-170
24. Benzene ethylbenzene, toluene, xylenes and TCE detected. p4-168
25. 62 F p2-2
26. Assumes annual evaporation is equal to net evaporation (41 in.). p2-2
27. Data not available. Assumed 5 mph.
28. Used most restrictive case. Figure 4-5, Table 4-9.
29. 90 days
30. p1-11
31. p1-11

Site identification:

CONTAMINANT HAZARD -- SURFACE WATER

If contaminants have been detected in surface water (score of 100 in item 1), complete items 36 through 41. If contaminants have not been detected (score of 0 in item 1, complete items 42 through 45. Attach Surface/Ground Water Worksheet or list of contaminants as appropriate.

	Score (circle one)	Result
36. Sum of human health hazard quotients (from column 10 of Hazard Worksheet.		-----
37. Human health hazard score.	0 1 2 4 6	-----
38. Normalized human health hazard score (multiply item 37 x 100/6).		-----
39. Sum of ecological hazard quotients (enter the larger of the sume of column 11 or 12 of Hazard Worksheet).		-----
40. Ecological hazard score.	0 1 2 3 4 5 6	-----
41. Normalized ecological hazard score (multiply item 40 x 100/6).		-----

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42. Maximum human health hazard index.	0 1 2 3 4 5 6 7 8 9	Contaminant: Benzene
43. Normalized human health hazard score (multiply item 42 x 100/9).		22.22
44. Maximum ecological hazard index.	0 1 2 4 6	Contaminant: Benzene
45. Normalized ecological hazard score (multiply item 44 x 100/6).		33.33

Site identification:

CONTAMINANT HAZARD -- GROUND WATER

If contaminants have been detected in ground water (score of 100 in item 13), complete items 46 through 51. If contaminants have not been detected (score of 0 in item 13), complete items 52 through 55. Attach Surface/Ground water Hazard Worksheet or list of contaminants as appropriate.

	Score (circle one)	Result
46. Sum of human health hazard quotients (from column 10 of Hazard Worksheet		-----
47. Human health hazard score	0 1 2 4 6	-----
48. Normalized human health hazard score (multiply item 47 x 100/6)		-----
49. Sum of ecological hazard quotients (enter the larger of the sum of column 11 or 12 of Hazard Worksheet)		-----
50. Ecological hazard score	0 1 2 3 4 5 6	-----
51. Normalized ecological hazard score (multiply item 50 x 100/6).		-----

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	Score (circle one)	Result
52. Maximum human health hazard index.	0 1 2 3 4 5 6 7 8 9	Contaminant: Toluene
53. Normalized human health hazard score (multiply item 52 x 100/9).		22.22
54. Maximum ecological hazard index.	0 1 2 4 6	Contaminant: Toluene
55. Normalized ecological hazard score (multiply item 54 x 100/6).		16.67

Site identification:

CONTAMINANT HAZARD -- AIR/SOIL

If contaminants have been detected in ambient air (score of 100 in item 23) or if volatile contaminants have been detected in site (score of 3 in item 24 complete items 56 through 61. If contaminants have not been detected (score of 0 in item 23 and item 24, complete items 62 through 65. Attach Air Hazard Worksheet or list of contaminants as appropriate.

	Score (circle one)	Result
56. Sum of human health hazard quotients (from column 6 of Hazard Worksheet		22.50
57. Human health hazard score	0 1 2 4 6	
58. Normalized human health hazard score (multiply item 57 x 100/6)		66.67
59. Sum of ecological hazard quotients (enter the sum of column 11 of Air Hazard Worksheet		0
60. Ecological hazard score.	0 1 2 3 4 5 6	
61. Normalized ecological hazard score (multiply item 60 x 100/6).		0

---

62. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant:________
63. Normalized human health hazard score (multiply item 62 x 100/9)		-----
64. Maximum ecological hazard index	0 1 2 4 6	Contaminant:________
65. Normalized ecological hazard score (multiply item 64 x 100/6)		-----

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Site identification:

HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
66. Population that obtains drinking water from potentially affected surface water body(ies) downstream	0 1 2 3	3	0	9
67. Water use of nearest surface water body(ies)	0 1 2 3	3	6	9
68. Population within 1500 ft (458 m) of the site	0 1 2 3	1	3	3
69. Distance to the nearest installation boundary column 7 of Hazard Worksheet)	0 1 2 3	1	2	3
70. Land use and/or zoning within 2 miles (3.2 km) of the site	0 1 2 3	1	3	3
71. Sum of items 66 through 70			14	27
72. Final score for human health receptors on surface water pathways (multiply item 71 x 100/27)			51.85	

ECOLOGICAL RECEPTORS -- SURFACE WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
73. Importance/sensitivity of biota/habitats in potentially affected surface water bodies nearest the site	0 1 2 3	5	10	15
74. Presence of "critical environments" within 1.5 miles (2.4 km) of the site	0 3	1	0	3
75. Sum of items 73 and 74			10	18
76. Final score for ecological receptors on surface water pathways (multiply item 75 X 100/18)			55.55	

COMMENTS ON SURFACE WATER RECEPTORS

66. No evidence that surface water is used to provide drinking water.
67. Surface water may be used for irrigation.
68. Population within 1 mile of site is approximately 2470.
69. Map Figure 1-3.
70. Land use is predominately agricultural.
73. Due to high level of irrigation.

Site identification:

HUMAN HEALTH RECEPTORS -- GROUND WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
77. Estimated mean ground water travel time from waste location to nearest downgradient water supply well(s)	0 1 2 3	9	18	27
78. Estimated mean ground water travel time from current waste location to any downgradient surface water body that supplies water for domestic use or for food chain agriculture	0 1 2 3	5	10	15
79. Ground water use of the uppermost aquifer.	0 1 2 3	4	12	12
80. Population potentially at risk from ground water contamination	0 3 6 9 12 18 24 27 36	1	36	36
81. Population within 1000 ft . (305 m) of the site	0 1 2 3	1	3	3
82. Distance to the nearest installation boundary	0 1 2 3	1	2	3
83. Sum of items 77 through 82			81	96
84. Final score for human health receptors on ground water pathways (multiply item 83 x 100/96)			84.375	

ECOLOGICAL RECEPTORS -- GROUND WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
85. Estimated mean ground water travel time from waste location to any downgradient habitat or natural area	0 1 2 3	3	0	9
86. Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected ground water discharge points	0 1 2 3	3	6	9

Site identification:

ECOLOGICAL RECEPTORS -- GROUND WATER PATHWAYS (concluded)

	Score (circle one)		Multiplier	Product (score x mult.)	Max. score
87. Presence of "critical environments" within 1.5 miles (2.4 km) of the site	0	3	1	0	3
88. Sum of items 85 and 87.				6	21
89. Final score for ecological receptors on ground water pathways (multiply item 88 x 100/21)				28.57	

COMMENTS ON GROUND WATER RECEPTORS (attach additional pages if needed)

77. No maps provided answer. Estimated aquifer porosity to wells (0.2), hydraulic conductivity (pp. 2-23, 2-25)

78. Based on conductivity, gradient and distance plus porosity (13.58) yrs).

80. 28035

82 3500 feet.

85. See 77.

86. See 78.

Site identification:

HUMAN HEALTH RECEPTORS -- AIR/SOIL PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
90. Population within 4 miles radius	0 9 12 15 18 21 24 27 30	1	30	30
91. Land use	0 1 2 3	2	4	6
92. Distance to nearest installation boundary	0 1 2 3	1	2	3
93. Sum of items 90 through 92			36	39
94. Final score for human health receptors on air pathways (multiply item 93 x 100/39)			92.19	

ECOLOGICAL RECEPTORS -- AIR/SOIL PATHWAYS

	Score	Multiplier	Product	Max. score
95. Distance to sensitive environment	0 1 2 3	2	0	6
96. Presence of "critical environments" within 1.5 miles (2.4 km) of the site	0 3	1	0	3
97. Sum of items 95 and 96			0	9
98. Final score for ecological receptors on air pathways (multiply item 97 x 100/9)			0	

COMMENTS ON AIR/SOIL PATHWAY RECEPTORS

90. Assumed worst case using info on page 2-5 and Map on 1-3.
91. One mile from residential area. p. 1-3.
92. Figure 1-3
93. No information available. Assume none.

Site identification:

SCORING SUMMARY SHEET

		Pathways score		Contaminant hazard score		Receptors score		Overall score
99.	Surface water/human health scores	(36.67 item 12	x	22.22 item 38/43	x	51.85 item 72	) /10,000=	4.22
100.	Surface water/ecological scores	(36.67 item 12	x	33.33 item 41/45	x	55.55 item 76	) /10,000=	6.79
101.	Ground water/human health scores	(56.14 item 22	x	22.22 item 48/53	x	84.375 item 84	) /10,000=	10.53
102.	Ground water/ecological scores	(56.14 item 22	x	16.67 item 51/55	x	28.57 item 89	) /10,000=	2.67
103.	Air/Soil human score	(80.56 item 35	x	66.67 item 58/63	x	92.19 item 94	) /10,000=	49.51
104.	Air/Soil ecological scores	(80.56 item 35	x	0 item 61/65	x	0 item 98	) /10,000=	0

OVERALL SITE SCORE:

105. $[(\underset{\text{item 99}}{\underline{4.22}})^2 \times 5 + (\underset{\text{item 100}}{\underline{6.79}})^2 + (\underset{\text{item 101}}{\underline{10.53}})^2 \times 5 + (\underset{\text{item 102}}{\underline{2.67}})^2 + (\underset{\text{item 103}}{\underline{49.5}})^2 \times 5 + (\underset{\text{item 104}}{\underline{0}})^2]^{1/2} = \underline{113.79}$

106. Overall site score = $\underset{\text{item 105}}{\underline{113.79}} / 4.24 = \underline{26.85}$

SURFACE/GROUNWATER HAZARD WORKSHEET

1	2	3	4	5	6	a 7	e 8	c 9	d 10	e 11	f 12
Contaminant name	Concentration (G/L)	Health effects benchmark (g/day)	Aquatic effects benchmark (g/L)	Terrestrial effects benchmark (g/L)	Bioaccumulation factor (L/kg)	Health Hazard Index	Aquatic Hazard Index	Terrestrial Hazard Index			
Toluene		24.0	175,000	-	83	1	2	1			
Benzene		30.0	5,300	-	32	2	2	2			
									Sum=	Sum=	Sum =

a (col 2) x (2 L/day)
b (col 2) x (col 6) x (0.0065 kg/day)
c (col 7) + (col 8)
d (col 9) / (col 3)
e (col 2) / (col 4)
f (col 2) / (col 5)

AIR/SOIL HAZARD WORKSHEET

1 Contaminant name	2 VOC air concentration (g/m3)	3 Soil concentration (mg/Kg) (25 ft)	4 Fugitive dust air concentration (g/m^3)	5 Health effects benchmark (ug/day)	6 Terrestrial effects benchmark (ug/L)	7 Inhalation intake (ug/day)[a]	8 Soil Ingestion intake (ug/day)[b]	9 Total intake (ug/day)[c]	10 Health hazard quotient[d]	11 Terrestrial hazard quotient[e]
			.0103							
benzene	7.7×10^{-6}	29.8		30		160.56	4.91	165.47	5.52	
ethylbenzene	5.7×10^{-6}	105		16		135.20	17.32	152.53	9.53	
toluene	8.8×10^{-6}	55.8		2200		187.09	9.207	196.30	0.09	
xylenes	3.3×10^{-6}	298		24		127.41	49.17	176.58	7.36	
									22.50	
									Sum=	

a $[(\text{col } 2) + (\text{col } 4) \times (\text{col } 3) \times (10^{-6}\ Kg/mg)] \times (20\ m^3/day) \times (10^6\ ug/g)$
b $(\text{col } 3) \times (10^{-6}\ Kg/mg) \times (0.165\ g/day) \times (10^6\ ug/g)$
c $(\text{col } 7) + (\text{col } 8)$
d $(\text{col } 9) / (\text{col } 5)$
e $\{[(\text{col } 2) + (\text{col } 4) \times (\text{col } 3) \times (10^{-6}\ Kg/mg)] \times (1000)\} / (\text{col } 6)$

APPENDIX B

TABLES SUMMARIZING TOXICITY BENCHMARKS AND BIOACCUMULATION FACTORS

Table B.1. Summary of toxicity benchmarks and bioaccumulation factors for individual chemicals

Chemical	CAS No.	Health effects: Benchmark (μg/d)	Health effects: Source[a]	Aquatic life (μg/L)	Irrigated crops (μg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
Acenaphthene	83-32-9	0.40E+02	EPA	1,700		390.0	3	2
Acetone	67-64-1	0.40E+02	RASH	10,000		0.16	2	1
Aldicarb [Temik] [Carbanolate]	116-06-3	0.66E-02	RASH	—	—	—	—	—
Aldrin	309-00-2	0.90E-06	EPA	3.0	—	11,000.0	9	4
Aluminum	7429-90-5	3.00E+00	RASH	—	5,000	—	—	2
Antimony	7440-36-0	0.29E+03	EPA	9,000	—	1.0	—	2
Arsenic	7440-38-2	0.04E+00	EPA	360	100	280.0	4	2
Barium	7440-39-3	1.50E-01	ACGIH	14,500		4.0	2	1
Baygon	38777-13-8	0.12E+00	RASH	13	5,000	8.5	2	2
Benzene	71-43-2	0.30E+02	EPA	5,300	—	32.0	2	2
Benzidine	92-87-5	0.34E-02	EPA	2,500	—	41.0	5	2
Benzo(a)anthracene	See Hydrocarbons							
Benzo(a)pyrene	See Hydrocarbons							
Beryllium	7440-41-7	0.17E+00	EPA	130	100	2.0	2	2
BHC and Isomers	See Hexachlorocyclohexane							
Bis(2-chloroethyl) ether [dichloroethylether]	111-44-4	0.84E+00	EPA	54,400	1,640,000	11.0	3	1
Bis(2-ethylhexyl) phthalate	See Phthalate esters							
Bromochloromethane	See Halomethanes							
Bromodichloromethane	See Halomethanes							
2-Butanone	See Methyl ethyl ketone							
Butyl benzyl phthalate	See Phthalate esters							
2-Butyl 1-octanol	See Hydrocarbons							
Cadmium	7440-43-9	0.20E+02	EPA	0.66	10	50.0	2	6
Carbaryl [Sevin]	63-25-2	0.18E+01	RASH	1.7	—	200.0	4	4
Carbon tetrachloride	56-23-5	0.52E+01	EPA	35,200	—	23.0	2	1
Chlordane	57-74-9	0.24E-02	EPA	2.4	—	1,400,000	7	4
Chlorinated benzenes	--	—		250.0	—	—	—	2
Chlorobenzene	108-90-7	0.26E+04	EPA	15,900	—	450	1	1
Dichlorobenzene	--	—		1,120	—		—	2
1,2-Dichlorobenzene [o-dichlorobenzene]	95-50-1	0.46E+03	EPA	1,580	—	560	2	2
1,3-Dichlorobenzene	None	0.46E+03	EPA	2,850	—	740	2	2
1,4-Dichlorobenzene [p-dichlorobenzene]	106-46-7	0.46E+03	EPA	1,120	—	690	2	2
Trichlorobenzene	—	—		1,500	—	—	—	2
1,2,4-Trichlorobenzene	120-82-1	0.74E+02	EPA	1,500	—	1,200	4	2

Table B.1. (continued)

Chemical	CAS No.	Health effects Benchmark (µg/d)	Source[a]	Aquatic life (µg/L)	Irrigated crops (µg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
Chlorinated ethanes	--	--		980	—	—	--	2
Chloroethane	75-00-3	0.10E+02	EPA	980	–	6.5	1	2
Dichloroethane	--	—		118,000	—	—	—	1
1,1-Dichloroethane [ethylidene chloride]	75-34-3	0.15E+02	EPA	118,000	—	14.0	2	1
1,2-Dichloroethane [ethylene chloride]	107-06-2	0.40E+02	EPA	118,000	—	2.0	1	1
Trans-1,2-dichloroethane	--	--	—	118,000	—	2.0	—	1
Trichloroethane								
1,1,1-Trichloroethane [methyl chloroform]	71-55-6	0.90E+02	EPA	31,200	—	8.9	1	1
1,1,2-Trichloroethane	79-00-5	1.20E+01	CAG	18,000	—	9.0	1	1
1,1,2-Trifluoro-1,2-di chloroethane	354-23-4	7.10E-03	RASH	—	—	200	6	—
Tetrachloroethane								
1,1,2,2-Tetra-chloroethane	79-34-5	0.10E+02	EPA	9,320	—	7.9	1	2
Pentachloroethane	76-01-7	0.36E+01	EPA	7,240	—	68.0	2	2
Hexachloroethane	67-72-1	0.36E+01	EPA	980	—	140.0	3	2
Chloroform [trichloro-methane][Freon-20]	67-66-3	0.42E+01	EPA	28,900	—	6.0	1	1
Chloroethane	See Chlorinated ethanes							
2-Chloronaphthalene	91-58-7	4.00E+00	RASH	1,600	—	—	—	2
Chromium	7440-47-3	0.16E-01	EPA	16	100	200.0	6	4
Chromium (III)	16065-83-1	0.16E-01	EPA	980	100	200.0	6	2
Chromium (VI)	18540-29-9	0.16E-01	EPA	16	100	200.0	6	4
1,2-Cis-dichloroethylene	See Dichloroethylenes							
Copper	7440-50-8	0.20E+04	EPA	9.2	200	210.0	1	4
Cyanides	Several	0.40E+03	EPA	22	—	0	0	4
Sodium cyanide	143-33-9	0.96E-01	RASH	—	—	0	2	—
Potassium cyanide	151-50-8	0.32E+00	RASH	—	—	0	2	—
Hydrocyanic acid	74-90-8	0.94E-01	RASH	—	—	0	2	—
Isocyanide (ion)	57-12-5	0.50E+00	RASH	—	—	0	2	—
Cyclohexane	See Hydrocarbons							
Cyclotetramethylene tetranitramine	See HMX							
2,4-D [dichlorophenoxy-acetic acid]	94-75-7	0.22E+00	RASH	1,850	22.1	140	4	4

Table B.1. (continued)

Chemical	CAS No.	Health effects Benchmark (μg/d)	Source[a]	Aquatic life (μg/L)	Irrigated crops (μg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
DDT [dichlorodiphenyl-trichloroethane]	50-29-3	0.56E-02	EPA	1.1	--	34,000	7	4
DDE [1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene]	72-55-9	0.40E+00	RASH	--	--	18,000,000	5	—
DDE [1,1-bis(p-chloro-phenyl) ethane]	3547-04-4	0.26E+00	RASH	--	—	—	—	—
DDD [1,1-dichloro-2,2-bis(p-chlorophenyl) ethane]	72-54-8	0.56E+00	RASH	—	—	170,000	5	—
2,4-DDD [2,4-dichloro-phenyl dichloroethane]	53-19-0	1.4E+01	RASH	—	--	—	—	—
Diazinon	333-41-5	0.2E+00	RASH	0.03	5,000	29	3	6
Dibromochloromethane	See Halomethanes							
Dibromomethane	See Halomethanes							
1,2-Dibromomethane	See Ethylene dibromide							
1,2-Dichlorobenzene	See Chlorinated benzenes							
1,3-Dichlorobenzene	See Chlorinated benzenes							
1,4-Dichlorobenzene	See Chlorinated benzenes							
Dichlorobromomethane	See Halomethanes							
Dichlorodifluoromethane	See Halomethanes							
1,1-Dichloroethane	See Chlorinated ethanes							
1,2-Dichloroethane	See Chlorinated ethanes							
Dichloroethylene	--	—	—	11,600	—	—	—	1
1,1-Dichloroethylene [Vinylidine chloride]	75-35-4	0.26E+01	EPA	11,600	—	7.2	1	1
1,2-Dichloroethylene	540-59-0	0.26E+01	EPA	135,000	—	7.2	1	1
1,2-Cis-dichloro ethylene	156-59-2	0.26E+01	EPA	135,000	2E+08	7.2	1	1
1,2-Trans-dichloro-ethylene	156-60-5	0.26E+01	EPA	135,000	—	7.2	1	1
Dichloroethylether	See Bis(2-chloroethyl)ether							
Dichlorofluoromethane	See Halomethanes							
Dichloromethane	See Halomethanes							
Dichloropropane	--	—	—	23,000	—	—		
1,2-Dichloropropane [propylene dichloride]	78-87-5	0.11E+04	EPA	52,500	1.5E+08	43	1	1
Dieldrin	60-57-1	0.90E-06	EPA	2.5	1,150	14,000	9	2

Table B.1. (continued)

Chemical	CAS No.	Health effects Benchmark (µg/d)	Source[a]	Aquatic life (µg/L)	Irrigated crops (µg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
Diethyl phthalate	See Phthalate esters							
2,4-Dimethylphenol [2,4-xylenol] [m-xylenol]	105-67-9	0.96E+01	RASH	2,120	—	150	3	2
Di-n-butyl phthalate	See Phthalate esters							
Dinitrobenzene	See Nitroaromatics							
Dinitrophenol	See Nitroaromatics							
Dinitrotoluene	See Nitroaromatics							
Dioctyl adipate	123-79-5	7.23E+01	RASH					
Dioxin [TCDD] [2,3,7,8-tetrachloro-dibenzo-p-dioxin]	1746-01-6	0.92E-08	EPA	—	—	9,300	9	—
Endosulfan II	--	--	--	0.22	—	—	—	6
Endrin	72-20-8	0.20E+01	EPA	0.18	--	2,600	4	6
Ethyl benzene [phenylethane]	100-41-4	0.22E+04	EPA	32,000	—	290	1	1
Ethylene chloride	See Chlorinated ethanes							
Ethylene dibromide [1,2-dibromoethane]	106-93-4	0.20E-01	CAG	15,000	—	2.5	2	1
Ethylene glycol [ethylene alcohol]	107-21-1	0.36E+02	RASH	5E+07	--	0.0039	1	0
Fluoranthene	206-44-0	0.40E+03	EPA	3,980	--	—	—	2
Formaldehyde	50-00-0	0.17E+01	RASH	15,000	—	0.28	2	1
Freon-11, Freon-30	See Halomethanes							
Freon-20	See Chloroform							
Freon-113	See Trichlorotrifluoroethane							
Halomethanes	--	—		11,000	—	—	—	1
Bromochloromethane [chlorobromomethane]	74-97-5	0.40E+01	EPA	67,000	—	7.4	1	1
Bromodichloromethane [dichlorobromomethane]	75-27-4	0.40E+01	EPA	11,000	—	17.	2	1
Dibromochloromethane	124-48-1	0.40E+01	EPA	11,000	—	28.	2	1
Dibromomethane [methylene bromide]	74-95-3	0.40E+01	EPA	11,000	50,000	—	—	1
Methylene chloride [dichloromethane] [Freon-30]	75-09-2	0.40E+01	EPA	193,000	—	4.4	1	1

Table B.1. (continued)

Chemical	CAS No.	Health effects: Benchmark (µg/d)	Health effects: Source[a]	Aquatic life (µg/L)	Irrigated crops (µg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
Dichlorofluoromethane	75-43-4	1.16E+02	RASH	11,000	—	8.0	1	1
Dichlorodifluoromethane	75-71-8	2.07E+02	RASH	11,000	—	32	1	1
Trichlorofluoromethane (Freon-11)	75-69-4	0.11E+02	EPA	11,000	—	74	2	1
Heptachlor	76-44-8	0.46E-03	EPA	0.52	--	14,000	7	4
Heptachlor epoxide	1024-57-3	0.34E+00	RASH	0.52	--	14,000	5	4
Hexane	See Hydrocarbons							
Hexachlorocyclohexane (BHC)	608-73-1	0.42E-03	EPA	100	--	1,000	7	2
α-Isomer	319-84-6	0.56E-01	CAG	100	—	710	4	2
-Isomer	319-85-7	0.32E+00	CAG	100	—	720	4	2
γ-Isomer (Lindane)	58-89-9	0.44E+00	CAG	2.0	1,000	1,000	5	4
Hexachloromethane	See Chlorinated ethanes							
Hexadecanoic acid	57-10-3	6.00E-01	RASH	12,000	—	—	—	1
HMX (cyclotetramethylene tetranitramine)	2691-41-0	3.30E+00	RASH	32,000	—	—	—	1
Hydrazine	302-01-2	0.56E-01	RASH	40	—	0.026	2	4
Hydrocarbons								
Benzo(a)anthracene	56-55-3	6.00E-02	RASH	10	—	—	—	4
Benzo(a)pyrene	50-32-8	6.00E-02	EPA	5		30	3	4
Cyclohexane	--	--		32,710	76,440	550	—	1
Methylcyclohexane	--	--		41,000	—	—	—	1
Hexane	--	--		177,500	--	—	—	1
Octane	--	--		100,000	--	—	—	1
Pentane	--	--		100,000	59,340	490	—	1
Pyrene	129-00-1	6.00E+00	RASH	—	—	0.8	1	—
Propylbenzene	--	--		91,400	—	940	4	1
2-Methyl-1,3-butadiene (isoprene)	--	--		42,540	—	—	—	1
2-Butyl-1-octanol	3913-02-8	6.82E+01	RASH					
Isophorone	78-59-1	0.92E+03	EPA	117,000	100	7.1	0	2
Iron	1309-37-1	1.50E+02	RASH	400	5,000	100	2	2
4-Hydroxyazobenzene	1689-82-3	6.50E-01	RASH	—	—	—	—	—
Lead	7439-92-1	0.10E+03	EPA	34	5,000	300	3	4
Lindane	See Hexachlorocyclohexane							
Malathion	121-75-5	0.24E+01	RASH	0.5	—	160	3	6
Manganese	7439-96-5	2.50E-01	CAG	350	200	400	4	2
Mercury	7439-97-6	0.40E+00	EPA	2.4	—	63,000	5	4

Table B.1. (continued)

Chemical	CAS No.	Health effects Benchmark (µg/d)	Source[a]	Aquatic life (µg/L)	Irrigated crops (µg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
Methoxychlor	72-43-5	0.16E+02	RASH	0.50	—	8,300	4	6
2-Methyl-1,3-butadiene	See Hydrocarbons							
Methyl cellosolve [2-methoxyethanol]	109-86-4	0.20E+01	RASH	17,400,000	—	0.050	1	—
Methylcyclohexane	See Hydrocarbons							
Methylene chloride	See Halomethanes							
Methyl ethyl ketone [2-butanone]	78-93-3	0.20E+02	RASH	5,600,000	—	0.60	1	0
Methyl isobutyl ketone	108-10-1	0.19E+02	RASH	460,000	—	6.2	1	4
Naphthalene [Naphthene]	91-20-3	0.28+03	EPA	2,300	—	430	2	2
Nickel	7440-02-0	0.26E+03	EPA	1,100	200	100	2	2
Nitroaromatics								
1,3-Dinitrobenzene	99-65-0	8.30E-01	RASH	7,400	—	7	2	2
1,3,5-Trinitrobenzene	99-35-4	2.20E+00	RASH	1,030	—	6	1	2
2-Amino-4,6-dinitro toluene	35572-78-2	—		4,500	—	3	—	2
2,4-Dinitrotoluene	81121-14-2	2.90E-01	RASH	13,900	—	25	3	1
2,6-Dinitrotoluene	606-20-2	1.60E+00	RASH	14,000	—	22	2	1
2,4,6-Trinitrotoluene	118-96-7	6.50E+00	RASH	2,850	—	16	2	2
2,4,6-Trinitrophenol (picric acid)	88-89-1	1.20E+00	RASH	85,000	—	—	—	1
2,4,6-Trinitroresorcinol (styphnic acid)	82-71-3	—		3,000,000	—	—	—	0
2,4-Dinitrophenol	51-28-5	2.00E-01	RASH	620	—	—	—	2
4-Nitrophenol	100-02-7	7.00E-01	RASH	8,280	—	—	—	2
Nitroglycerin	55-63-0	5.45E+00	RASH	1,670	—	15	2	2
Nitrosamines	—	—		5,850	—	81	—	2
n-Nitrosodimethylamine	62-75-9	0.15E-00	EPA	280,000	—	0.078	2	1
n-Nitrosodiphenylamine	86-30-6	0.19E+01	RASH	5,850	—	81	3	2
Octadecanoic acid	57-11-4	5.71E+00	RASH	—	—	—	—	—
Octane	See Hydrocarbons							
PCBs [polychlorinated biphenyls] [chlorodiphenyls]	Several	0.52E-3	EPA	2.0		10,000,000	7	4
Pentachloroethane	See Chlorinated ethanes							
Pentachlorophenol [PCP]	87-86-5	0.28E+03	EPA	55	37,300	780	2	4
Pentane	See Hydrocarbons							

Table 8.1. (continued)

Chemical	CAS No.	Health effects Benchmark (µg/d)	Health effects Source[a]	Aquatic life (µg/L)	Irrigated crops (µg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
Perchloroethylene	See Tetrachloroethylene							
PETN (pentaerythritol tetranitrate)	78-11-5	3.20E+03	RASH	—	—	—	—	—
Phenol [carbolic acid]	108-95-2	0.68E+04	EPA	10,000	—	1.7	0	1
Phthalate esters	--	--		940	—	—	—	2
Bis(2-ethylhexyl) phthalate	117-81-7	0.10E+05	EPA	160	—	310	1	2
Butyl benzyl phthalate	85-68-7	0.10E+05	EPA	1,700	—	660	1	2
Diethyl phthalate	84-66-2	0.10E+05	EPA	52,100	—	120	0	1
Di-n-butyl phthalate	84-74-2	0.10E+05	EPA	940	—	89	1	2
Picric acid	See Nitroaromatics							
Potassium nitrate	7757-79-1	1.20E+01	RASH	5,400	—	—	—	2
Propylbenzene	See Hydrocarbons							
Pyrene	See Hydrocarbons							
RDX [cyclonite,] [cyclotrimethylene trinitroamine]	121-82-4	2.10E+00	RASH	5,200	—	5	1	2
Selenium	7782-49-2	0.20E+02	EPA	260	—	8.3	1	2
Sevin	See Carbaryl							
Silver	7440-22-4	0.20E+02	EPA	1.2	—	2.0	1	4
Sodium (I) nitrate (1:1)	7651-99-4	3.80E+02	RASH	—	—	—	—	—
2,4,5-T [2,4,5-trichloro-phenoxyacetic acid]	93-76-5	0.11E+01	RASH	100	25,500	470	4	2
2,4,5-TP [Silvex] [2,4,5-trichlorophenoxy-propionic acid]	93-72-1	0.20E+01	RASH	340	770	1,400	4	2
Temik	See Aldicarb							
Tetrachloroethane	See Chlorinated ethanes							
Tetrachloroethylene [perchloroethylene]	127-18-4	0.40E+01	EPA	5,280	—	44	2	2
Tetrahydrofuran	109-99-9	2.07E+01	RASH	—	—	0.8	1	—
Tetryl	479-45-8	3.00E-02	RASH	2,400,000	—	—	—	0
Tetraethyl lead	78-00-2	1.03E-01	RASH	230	—	—	—	2
Thallium	7440-28-0	0.80E+01	EPA	—	—	10,000	4	—
Toluene [methyl benzene]	108-88-3	0.24E+02	EPA	17,500	—	83	2	1
Trans-1,2-dichlorethane	See Chlorinated ethanes							
Trans-1,2-dichloroethylene	See Dichloroethylene							

Table B.1. (continued)

Chemical	CAS No.	Health effects Benchmark (μg/d)	Health effects Source[a]	Aquatic life (μg/L)	Irrigated crops (μg/L)	Fish bio-accumulation (L/kg)	Health hazard score	Ecological hazard score
1,2-Trans-dichloroethylene	See Dichloroethylene							
1,2,4-Trichlorobenzene	See Chlorinated benzenes							
Trichloroethane	See Chlorinated ethanes							
1,1,1-Trichloroethane	See Chlorinated ethanes							
Trichloroethylene	79-01-6	0.42E+02	EPA	45,000	--	17	2	1
Trichlorofluoromethane	See Halomethanes							
Trichloromethane	See Chloroform							
Trichlorotrifluoroethane [Freon-113]	76-13-1	0.12E+02		--	--	480	3	--
Tricresyl phosphate [TCP]	1330-78-5	0.56E+01	RASH	7,000,000	--	170	3	0
1,1,2-Trifluoro-1,2-dichloroethane	See Chlorinated ethanes							
Trinitrobenzene	See Nitroaromatics							
Trinitrophenol	See Nitroaromatics							
Trinitroresorcinol	See Nitroaromatics							
Trinitrotoluene	See Nitroaromatics							
UDMH [unsymmetrical dimethyl hydrazine] [1,1-dimethylhydrazine]	57-14-7	0.44E+00	RASH	4,700	--	0.36	2	2
Vanadium	1314-62-1	1.50E-02	ACGIH	4,800	100	0.01	2	2
Vinyl chloride	75-01-4	0.10E+04		381,000	--	7.2	0	1
Xylene	1330-20-7	0.16+02	RASH	13,500	--	320	3	1
m-Xylene	108-38-3	0.16E+02	RASH	13,500	--	320	3	1
o-Xylene	95-47-6	0.36E+02	RASH	13,500	--	190	3	1
p-Xylene	106-42-3	0.15+02	RASH	13,500	--	290	3	1
2,4-Xylenol, m-xylenol	See 2,4-Dimethylphenol							
Zinc	7440-66-6	0.10E+05	EPA	180	2,000	1,000	2	4

[a]Source of health effects, benchmarks were Environmental Protection Agency water criteria documents (EPA), EPA Carcinogen Assessment Group publications (CAG), American Council of Governmental Industrial Hygienists (ACGIH), and relative potency estimates (RASH), T. D. Jones, P. J. Walsh, A. P. Watson, L. W. Barnthouse, and D. A. S[illegible]ders, "Chemical Scoring by a Rapid Screening Hazard (RASH) Method," J. Risk Analysis (in press).

Table B.2. Summary of toxicity benchmarks and bioaccumulation factors for complex mixtures

	Health effects (µg/D)	Aquatic life (µg/L)	Fish bioaccumulation (L/kg)	Hazard score	
				Health	Ecological
Diesel fuel	3.47E+01	970	--	--	2
Diesel fuel (marine)	1.71E+02	2,900	--	--	2
Gasoline	1.54E+01	8,000	--	--	2
Heavy fuel oil	1.50E+01	2,400,000	--	--	0
Hydraulic fluid (glycol)	3.53E+01	1,700,000	--	--	0
Hydraulic fluid (organophosphate)	1.36E+01	1,300	2000	4	2
Jet fuel	1.30E+01	28,800	120	3	1
JP-4	1.30E+01	28,800	120	3	1
JP-7	3.33E+02	28,800	120	2	1
Kerosene	1.05E+02	200,000	--	--	1
Light heating oil	6.00E+01	970	--	--	2
Lubricating oil	9.68E+00	2,500	--	--	2
Motor oil (new, used)	6.19E+01	--	--	--	--
Stoddard solvent (mineral spirits)	6.67E+00	--	--	--	--

[a]C. E. Easterly and L. R. Glass, "Toxicity of Petroleum Products as Predicted with a Relative Potency Methodology," Fundamental and Applied Toxicology (in press).

APPENDIX C

INDEX OF ASSESSED COMPOUNDS

Table C.1. Index of assessed compounds by CAS number

CAS No.	Chemical name
50-00-0	Formaldehyde
50-29-3	Dichlorodiphenyltrichloro-ethane [p,p-DDT]
50-32-8	Benzo(a)pyrene
51-28-5	2,4-Dinitrophenol
53-19-0	2,4-Dichlorophenyldichloroethane [2,4-DDD]
55-63-0	Nitroglycerin
56-23-5	Carbon tetrachloride
56-55-3	Benzo(a)anthracene
57-10-3	Hexadecanoic acid
57-11-4	Octadecanoic acid
57-12-5	Cyanide [isocyanide]
57-14-7	Unsymmetrical dimethylhydrazine [UDMH] [1,1-dimethylhydrazine]
57-74-9	Chlordane
58-89-9	Benzene hexachloride [BHC] γ-isomer [Lindane] [see hexachlorocyclohexane]
60-57-1	Dieldrin
62-75-9	N-Nitrosodimethylamine
63-25-2	Carbaryl [Sevin]
67-64-1	Acetone
67-66-3	Chloroform [trichloromethane] [Freon-20]
67-72-1	Hexachloroethane
71-43-2	Benzene
71-55-6	1,1,1-Trichloroethane [methyl chloroform]

Table C.1. (continued)

CAS No.	Chemical name
72-20-8	Endrin
72-43-5	Methoxychlor
72-54-8	1,1-Dichloro-2,2-bis (p-chlorophenyl) ethane [p,p-DDD]
72-55-9	1,1-Dichlor-2,2-bis (p-chlorophenyl) ethylene [p,p-DDE]
74-90-8	Hydrocyanic acid
74-95-3	Dibromomethane [methylene dibromide] [methylene bromide]
74-97-5	Bromochloromethane [chlorobromo-methane]
75-01-4	Vinyl chloride [chloroethylene]
75-09-2	Methylene chloride [dichloromethane] [Freon-30]
75-27-4	Bromodichloromethane [dichlorobromomethane]
75-34-3	1,1-Dichloroethane [ethylidene chloride]
75-35-4	1,1-Dichloroethylene [vinylidine chloride]
75-43-4	Dichlorofluoromethane
75-69-4	Trichlorofluoromethane [Freon-11]
75-71-8	Dichlorodifluoromethane
76-01-7	Pentachloroethane
76-13-1	Trichloro-trifluoroethane [Freon-113]
76-44-8	Heptachlor

Table C.1. (continued)

CAS No.	Chemical name
77-47-4	Hexachlorocyclopentadiene [1,2,3,4,5,5-hexachloro 1,3-cyclopentadiene]
78-59-1	Isophorone
78-00-2	Tetraethyl lead
78-11-5	Pentaerithritol tetranitrate (PETN)
78-87-5	1,2-Dichloropropane [Propylene dichloride]
78-93-3	Methyl ethyl ketone [2-butanone]
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethylene
79-34-5	1,1,2,2-Tetrachloroethane [perchloroethylene]
82-71-3	2,4,6-Trinitroresorcinol [styphnic acid]
83-32-9	Acenaphthene
84-66-2	Diethyl phthalate
84-74-2	Di-n-butyl phthalate
85-68-7	Butyl-benzyl phthalate
86-30-6	N-Nitrosodiphenylamine
87-68-3	Hexachlorobutadiene [hexachloro 1,3-butadiene]
87-86-5	Pentachlorophenol
88-89-1	2,4,6-Trinitrophenol [picric acid]

Table C.1. (continued)

CAS No.	Chemical name
91-20-3	Naphthalene [Naphthene] [moth flakes]
91-58-7	2-Chloronaphthalene
92-87-5	Benzidine
93-72-1	2(2,4,5-Trichlorophenoxy) proprionic acid [Silvex]
93-76-5	2,4,5-Trichlorophenoxyacetic acid [2,4,5-T]
94-75-7	2,4-Dichlorophenoxyacetic acid [2,4-D]
95-47-6	O-Xylene
95-50-1	1,2-Dichlorobenzene [o-dichlorobenzene]
95-57-8	2-Chlorophenol [O-chlorophenol]
98-95-3	Nitrobenzene
99-35-4	1,3,5-Trinitrobenzene
99-65-0	1,3-Dinitrobenzene
100-02-7	4-Nitrophenol
100-41-4	Ethyl benzene [phenylethane]
103-23-1	Dioctyl adipate
105-67-9	2,4-Dimethylphenol [2,4-xylenol] [m-xylenol]
106-42-3	p-Xylene
106-46-7	1,4-Dichlorobenzene [p-dichlorobenzene]
106-93-4	Ethylene dibromide [1,2-dibromoethane]
107-02-8	Acrolein

Table C.1. (continued)

CAS No.	Chemical name
107-06-2	1,2-Dichloroethane [ethylene chloride]
107-13-1	Acrylonitrile
107-21-1	Ethylene glycol [ethylene alcohol]
108-10-1	Methyl isobutyl ketone
108-38-3	m-Xylene
108-88-3	Toluene [methylbenzene]
108-90-7	Chlorobenzene
108-95-2	Phenol [carbolic acid]
109-86-4	Methyl cellosolve [2-methoxyethanol]
109-99-9	Tetrahydrofuran
111-44-4	Bis(2-chloroethyl) ether [dichloroethyl ether]
115-29-7	Endosulfan [1,4,5,6,7,7-hexachloro-5-norbornene-2,3-dimethanol cyclic sulfite]
116-06-3	Aldicarb [Temik] [Carbanolate]
117-81-7	Bis (2-ethyl hexyl) phthalate
118-96-7	2,4,6-Trinitroroluene
120-82-1	1,2,4-Trichlorobenzene
120-83-2	2,4-Dichlorophenol
121-14-2	2,4-Dinitrotoluene
121-75-5	Malathion
121-82-4	Cyclonite [RDX]
122-66-7	1,2-Diphenyl hydrazine [Hydrazobenzene]

Table C.1. (continued)

CAS No.	Chemical name
124-48-1	Dibromochloromethane
127-18-4	Tetrachloroethylene [perchloroethylene]
129-00-0	Pyrene
143-33-9	Sodium cyanide
151-50-8	Potassium cyanide
156-59-2	1,2-cis-Dichloroethylene
156-60-5	1,2-trans-Dichloroethylene
206-44-0	Fluoranthene
302-01-2	Hydrazine
309-00-2	Aldrin
319-84-6	Benzene hexachloride [BHC] γ-isomer
319-85-7	Benzene hexachloride [BHC] φ-isomer
333-41-5	Diazinon
354-23-4	1,1,2-Trifluoro-1,2-dichloroethane
479-45-8	Tetryl
606-20-2	2,6-Dinitrotoluene
608-73-1	Hexachlorocyclohexane [1,2,3,4,5,6-hexachlorohexane] [BHC]
1024-57-3	Heptachlor epoxide
1300-21-6	Dichloroethane
1309-37-1	Iron
1314-62-1	Vanadium

Table C.1. (continued)

CAS No.	Chemical name
1330-20-7	Xylene
1330-78-5	Tricresyl phosphate [Cresol phosphate]
1689-82-3	4-Hydroxyazobenzene
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin [TCDD] [Dioxin]
2080-89-9	3-Ethyl-1,4-hexadione
2691-41-0	cyclotetramethylene tretranitramine [HMX]
3547-04-4	1,1-Bis(p-chlorphenyl)-ethane [DDE]
3913-02-8	2-Chloronaphthalone
7429-90-5	Aluminum
7439-89-6	Iron
7439-92-1	Lead
7439-96-5	Manganese
7439-97-6	Mercury
7439-98-7	Molybdenum
7440-02-0	Nickel
7440-22-4	Silver
7440-28-0	Thallium
7440-36-0	Antimony
7440-38-2	Arsenic
7440-39-3	Barium
7440-41-7	Beryllium
7440-42-8	Boron
7440-43-9	Cadmium

Table C.1. (continued)

CAS No.	Chemical name
7440-47-3	Chromium (metal)
7440-48-4	Cobalt
7440-50-8	Copper
7440-66-6	Zinc
7631-99-4	Sodium (I) nitrate (1:1)
7757-79-1	Potassium nitrate
7782-49-2	Selenium
16065-83-1	Chromium III (ion)
16984-48-8	Fluoride
18540-29-9	Chromium VI (ion)
25321-14-6	Dinitrotoluene
35572-78-2	2-Amino-4,6-dinitrotoluene
38777-13-8	Baygon
81121-14-2	2,4-Dinitrotoluene
Several	Cyanides
Several	PCBs polychlorinated biphenyls
None	1,3-Dichlorobenzene

APPENDIX D

SUMMARY OF ADDITIONAL CHEMICAL PROPERTY DATA FOR THE AIR AND SOIL PATHWAYS

Table D.1. Summary of Additional Chemical Property Data for the Air and Soil Pathways

Chemical	CAS No.	M.W.	Density (g/cc)	Vap. Press (mmHg)	Solubil (mg/l)	H Law Con (atm-m3/mol)
Acenaphthene	83-32-9	154.21	1.07	0.005	2	7.71E-03
Acetone	67-64-1	58.08	0.79	266		2.50E-05
Aldicarb [Temik] [Carbanolate]	116-06-3	190.29			6000	3.17E-08
Aldrin	309-00-2	364.93			0.01	3.65E-02
Aluminum	7429-90-5					
Antimony	7440-36-0					
Arsenic	7440-38-2					
Barium	7440-39-3					
Baygon	38777-13-8					
Benzene	71-43-2	78.1	0.87	95.2		5.50E-03
Benzidine	92-87-5					
Benzo(a)anthracene	See Hydrocarbons					
Benzo(a)pyrene	See Hydrocarbons					
Beryllium	7440-41-7					
BHC and Isomers	See Hexachlorocyclohexane					
Bis(2-chloroethyl) ether [dichloroethylether]	111-44-4	143.00	1.22	1.4		2.10E-04
Bis(2-ethylhexyl) phthalate	See Phthalate esters					
Bromochloromethane	See Halomethanes					
Bromodichloromethane	See Halomethanes					
2-Butanone	See Methyl ethyl ketone					
Butyl benzyl phthalate	See Phthalate esters					
2-Butyl 1-octanol	See Hydrocarbons					
Cadmium	7440-43-9					
Carbaryl [Sevin]	63-25-2					
Carbon tetrachloride	56-23-5	153.8	1.59	113		3.00E-02

Table D.1 (continued)

Chlordane	57-74-9	410.00	1.11	1.0E-05		3.67E-05
Chlorinated benzenes	--					
Chlorobenzene	108-90-7	112.56	1.11	11.8		3.93E-03
Dichlorobenzene	--					
1,2-Dichlorobenzene [o-dichlorobenzene]	95-50-1	147.00	1.31	1.5		1.94E-03
1,3-Dichlorobenzene	541-73-1	147.00	1.29	2.28		3.61E-03
1,4-Dichlorobenzene [p-dichlorobenzene]	106-46-7	147.00	1.46	1.2		1.60E-03
Trichlorobenzene	--					
1,2,4-Trichlorobenzene	120-82-1	181.50	0.00	0.18		1.42E-03
Chlorinated ethanes	--					
Chloroethane	75-00-3	64.52	0.92	1200		9.10E-03
Dichloroethane	--					
1,1-Dichloroethane [ethylidene chloride]	75-34-3	99.00	1.17	234	5500	5.54E-03
1,2-Dichloroethane [ethylene chloride]	107-06-2	98.76	1.26	82		1.20E-03
Trans-1,2-dichloroethane	--					
Trichloroethane						
1,1,1-Trichloroethane [methyl chloroform]	71-55-6	133.40	1.35	123		3.00E-02
1,1,2-Trichloroethane	79-00-5	133.40	0.00	25		7.42E-02
1,1,2-Trifluoro-1,2-di chloroethane	354-23-4					
Tetrachloroethane						
1,1,2,2-Tetra- chloroethane	79-34-5	168.00	1.60	6.5		3.80E-04
Pentachloroethane	76-01-7	202.30	1.67	4.4		2.10E-02
Hexachloroethane	67-72-1	237.00	2.09	0.65		2.49E-06
Chloroform [trichloro-methane][Freon-20]	67-66-3	119.40	1.49	208		3.39E-03
Chloroethane	See Chlorinated ethanes					
2-Chloronaphthalene	91-58-7	162.51		0.017	0.2	1.85E-02

Table D.1 (continued)

Chromium	7440-47-3				
Chromium (III)	16065-83-1				
Chromium (VI)	18540-29-9				
1,2-Cis-dichloroethylene	See Dichloroethylenes				
Copper	7440-50-8				
Cyanides	Several				
Sodium cyanide	143-33-9				
Potassium cyanide	151-50-8				
Hydrocyanic acid	74-90-8				
Isocyanide (ion)	57-12-5				
Cyclohexane	See Hydrocarbons				
Cyclotetramethylene tetranitramine	See HMX				
2,4-D [dichlorophenoxy-acetic acid]	94-75-7	221.04	289.5	890	6.21E-02
DDT [dichlorodiphenl-trichloroethane]	50-29-3	354.49		.0031	1.14E-01
DDE[1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene]	72-55-9				
DDE [1,1-bis(p-chloro-phenyl) ethane]	3547-04-4				
DDD [1,1-dichloro-2,2-bis(p-chlorophenyl) ethane]	72-54-8				
2,4-DDD [2,4-dichloro-phenyl dichloroethane]	53-19-0				
Diazinon	333-41-5				
Dibromochloromethane	See Halomethanes				
Dibromomethane	See Halomethanes				
1,2-Dibromomethane	See Ethylene dibromide				
1,2-Dichlorobenzene	See Chlorinated benzenes				
1,3-Dichlorobenzene	See Chlorinated benzenes				
1,4-Dichlorobenzene	See Chlorinated benzenes				
Dichlorohromomethane	See Halomethanes				

Table D.1 (continued)

Dichlorodifluoromethane	See Halomethanes					
1,1-Dichloroethane	See Chlorinated ethanes					
1,2-Dichloroethane	See Chlorinated ethanes					
Dichloroethylene	--					
1,1-Dichloroethylene [Vinylidine chloride]	75-35-4	97.00	1.21	630.1		1.2F-03
1,2-Dichloroethylene	540-59-0					
1,2-Cis-dichloro ethylene	156-54-2	96.95	1.28	200	800	3.19E-02
1,2-Trans-dichloro-ethylene	156-60-5					
Dichloroethylether	See Bis(2-chloroethyl)ether					
Dichlorofluoromethane	See Halomethanes					
Dichloromethane	See Halomethanes					
Dichloropropane	--					
1,2-Dichloropropane *[propylene dichloride]*	78-87-5	112.93	1.16	40		2.30E-03
Dieldrin	60-57-1					
Diethyl phthalate	See Phthalate esters					
2,4-Dimethylphenol [2,4-xylenol] [m-xylenol]	105-67-9					
Di-n-butyl phthalate	See Phthalate esters					
Dinitrobenzene	See Nitroaromatics					
Dinitrophenol	See Nitroaromatics					
Dinitrotoluene	See Nitroaromatics					
Dioctyl adipate	123-79-5					
Dioxin [TCDD] [2,3,7,8-tetrachloro-dibenzo-p-dioxin]	1746-01-6	322.00		1.00E-09	3.00E-11	1.41E+01
Endosulfan II	--					
Endrin	72-20-8					
Ethyl benzene [phenylethane]	100-41-4	106.16	0.86	10		6.44E-03
Ethylene chloride	See Chlorinated ethanes					

Table D.1 (continued)

Ethylene dibromide [1,2-dibromoethane]	106-93-4	187.88	2.70	14	4310	1.09E-02
Ethylene glycol [ethylene alcohol]	107-21-1	62.07	1.11	0.1256	1.0E+05	1.03E-07
Fluoranthene	206-44-0	202.00	1.20	1.63E-05	2	1.78E-06
Formaldehyde	50-00-0	30.00	1.08	3500		5.76E-05
Freon-11, Freon-30	See Halomethanes					
Freon-20	See Chloroform					
Freon-113	See Trichlorotrifluoroethane					
Halomethanes	--					
Bromochloromethane [chlorobromomethane]	74-97-5	129.39			10	2.59E+01
Bromodichloromethane [dichlorobromomethane]	75-27-4	163.80	1.97	59.15	200	2.05E-01
Dibromochloromethane	124-48-1	208.29	2.38		0.2	2.08E+03
Dibromomethane [methylene bromide]	74-95-3	173.85		48	1.1E+04	9.98E-04
Methylene chloride [dichloromethane] [Freon-30]	75-09-2	85.00	1.34	438		3.19E-03
Dichlorofluoromethane	75-43-4	102.92		1360	0.2	9.21E+02
Dichlorodifluoromethane	75-71-8	120.92	1.49	5000		4.02E-01
Trichlorofluoromethane [Freon-11]	75-69-4	137.40	0.00	796		5.83E-02
Heptachlor	76-44-8	373.35	1.57	3.0E-04		2.30E-03
Heptachlor epoxide	1024-57-3					
Hexane	See Hydrocarbons					
Hexachlorocyclohexane [BHC]	608-73-1					
o-Isomer	319-84-6					
-Isomer	319-85-7					
γ-Isomer [Lindane]	58-89-9	290.83	1.87	9.40E-06	17	7.80E-06
Hexachloromethane	See Chlorinated ethanes					
Hexadecanoic acid	57-10-3					
HMX (cyclotetramethylene tetranitramine)	2691-41-0					

Table D.1 (continued)

Hydrazine	302-01-2	32.06		14.4		6.66E-07
Hydrocarbons						
Benzo(a)anthracene	56-55-3	228.30	1.11	1.5E-07		1.38E-09
Benzo(a)pyrene	50-32-8	252.30	1.11	5.68E-04		1.38E-09
Cyclohexane	110-82-7	84.20	0.78	100		1.37E-02
Methylcyclohexane	109-87-2	98.00		43	2	2.77E+00
Hexane	110-54-3	86.20	0.66	150.3		1.22E-01
Octane	111-65-9	114.30	0.70	17	0.66	3.87E+00
Pentane	--					
Pyrene	129-00-1	202.30	1.27	4.20E-09	2	7.00E-09
Propylbenzene	103-65-1	120.19	0.86	2.5	60	6.59E-03
2-Methyl-1,3-butadiene (isoprene)	--					
2-Butyl-1-octanol	3913-02-8					
Isophorone	78-59-1	138.21	0.92	0.439		5.76E-06
Iron	1309-37-1					
4-Hydroxyazobenzene	1689-82-3					
Lead	7439-92-1					
Lindane	See Hexachlorocyclohexane					
Malathion	121-75-5					
Manganese	7439-96-5					
Mercury	7439-97-6					
Methoxychlor	72-43-5					
2-Methyl-1,3-butadiene	See Hydrocarbons					
Methyl cellosolve [2-methoxyethanol]	109-86-4					
Methylcyclohexane	See Hydrocarbons					
Methylene chloride	See Halomethanes					
Methyl ethyl ketone [2-butanone]	78-93-3	72.12	0.82	100		4.35E-05
Methyl isobutyl ketone	108-10-1	100.16	0.80	15.7	1.0E+04	4.95E-05
Naphthalene [Naphthene]	91-20-3	128.2	1.14			1.1[illegible]E-03
Nickel	7440-02-0					
Nitroaromatics						
1,3-Dinitrobenzene	99-65-0	168.10	1.56	0.05		2.20E-05

Table D.1 (continued)

1,3,5-Trinitrobenzene	99-35-4					
2-Amino-4,6-dinitro toluene	35572-78-2					
2,4-Dinitrotoluene	121-14-4	182.10	1.31	0.0051		4.07E-06
2,6-Dinitrotoluene	606-20-2					
2,4,6-Trinitrotoluene	118-96-7	227.10		0.046	1.00E+03	1.37E-05
2,4,6-Trinitrophenol (picric acid)	88-89-1					
2,4,6-Trinitroresorcinol (styphnic acid)	82-71-3					
2,4-Dinitrophenol	51-28-5	184.00	1.68	0.0051		4.07E-06
4-Nitrophenol	100-02-7	139.00	1.40	0.555	16	6.34E-03
Nitroglycerin	55-63-0	227.09	1.60	0.0036		6.00E-19
Nitrosamines	--					
n-Nitrosodimethylamine	62-75-9					
n-Nitrosodiphenylamine	86-30-6					
Octadecanoic acid	57-11-4					
Octane	See Hydrocarbons					
PCBs [polychlorinated biphenyls] [chlorodiphenyls]	Several					
Pentachloroethane	See Chlorinated ethanes					
Pentachlorophenol [PCP]	87-86-5	266.4	1.98	9.90E-04		2.80E-06
Pentane	See Hydrocarbons					
Perchloroethylene	See Tetrachloroethylene					
PETN (pentaerythritol tetranitrate)	78-11-5	316.17			10	3.16E-05
Phenol [carbolic acid]	108-95-2	94.10	1.07	0.341		4.54E-07
Phthalate esters	--					
Bis(2-ethylhexyl) phthalate	117-81-7					
Butyl benzyl phthalate	85-68-7	312.39			2.9	1.08E-02
Diethyl phthalate	84-66-2	222.00	1.12		2	1.11E-02
Di-n-butyl phthalate	84-74-2	278.30	1.47	1.00E-05		2.80E-07
Picric acid	See Nitroaromatics					

Table D.1 (continued)

Potassium nitrate	7757-79-1					
Propylbenzene	See Hydrocarbons					
Pyrene	See Hydrocárbons					
RDX [cyclonite,] [cyclotrimethylene trinitroamine]	121-82-4					
Selenium	7782-49-2					
Sevin	See Carbaryl					
Silver	7440-22-4					
Sodium (I) nitrate (1:1)	7651-99-4	69.00			1.00E+05	6.90E-10
2,4,5-T [2,4,5-trichloro-phenoxyacetic acid]	93-76-5					
2,4,5-TP [Silvex] [2,4,5-trichlorophenoxy-propionic acid]	93-72-1					
Temik	See Aldicarb					
Tetrachloroethane	See Chlorinated ethanes					
Tetrachloroethylene [perchloroethylene]	127-18-4	165.90	0.00	18.6		2.90E-02
Tetrahydrofuran	109-99-9	72.12	0.88	72.1		4.90E-05
Tetryl	479-45-8					
Tetraethyl lead	78-00-2	323.45		0.35		8.09E-02
Thallium	7440-28-0					
Toluene [methyl benzene]	108-88-3	92.00	0.87	30		6.68E-03
Trans-1,2-dichlorethané	See Chlorinated ethanes					
Trans-1,2-dichloroethylene	See Dichloroethylene					
1,2-Trans-dichloroethylene	See Dichloroethylene					
1,2,4-Trichlorobenzene	See Chlorinated benzenes					
Trichloroethane	See Chlorinated ethanes					
1,1,1-Trichloroethane	See Chlorinated ethanes					
Trichloroethylene	79-01-6	131.39	1.46	75		9.10E-03
Trichlorofluoromethane	See Halomethanes					
Trichloromethane	See Chloroform					
Trichlorotrifluoroethane [Freon-113]	76-13-1					

Table D.1 (continued)

Tricresyl phosphate [TCP]	1330-78-5					
1,1,2-Trifluoro-1,2-dichloroethane	See Chlorinated ethanes					
Trinitrobenzene	See Nitroaromatics					
Trinitrophenol	See Nitroaromatics					
Trinitroresorcinol	See Nitroaromatics					
Trinitrotoluene	See Nitroaromatics					
UDMH [unsymmetrical dimethyl hydrazine] [1,1-dimethylhydrazine]	57-14-7	60.10	0.80	157	1.00E+05	1.24E-04
Vanadium	1314-62-1					
Vinyl chloride	75-01-4	62.50	0.91	2660		8.60E-02
Xylene	1330-20-7	106.20		8.5		5.25E-03
m-Xylene	108-38-3	106.16	0.86	8		5.20E-03
o-Xylene	95-47-6	106.17	0.88	591		5.27E-03
p-Xylene	106-42-3	106.16	0.86	9.5		5.27E-03
2,4-Xylenol, m-xylenol	See 2,4-*Dimethylphenol*					
Zinc	7440-66-6					

APPENDIX E

LIST OF AIR FORCE BASES FOR WHICH METEOROLOGY DATA ARE INCLUDED IN THE ADPM

METEOROLOGY DATABASE

Facility	Type	ID	Annual Precipitation	Annual Evaporation	Rainfall (ins)
McChord AFB	MAC	MCHRD	40	23	2.20
Fairchild AFB	SAC	FRCHD	22	38	1.25
Malmstorm AFB	SAC	MLMSM	20	32	1.12
Mountian Home AFB	TAC	MOUNT	10	37	0.97
Francis E. Warren	SAC	FEWRN	14	41	1.37
Ellsworth AFB	SAC	ELSWH	14	41	1.60
Grand Forks AFB	SAC	GRDFK	20	27	1.8
Minot AFB	SAC	MINOT	15	32	1.52
Beale AFB	SAC	BEALE	0	44	4.0
McClellan AFB	AFLC	MCCLN	0	52	2.5
Mather AFB	ATC	MATHR	0	52	4.0
Travis AFB	MAC	TRAVS	0	52	2.3
Castle AFB	SAC	CASTL	0	60	2.8
Vandenburg AFB	SAC	VNDBG	0	44	2.0
Edwards AFB	AFSC	EDWRD	0	66	1.75
George AFB	TAC	GEORG	0	86	0.75
Los Angeles AFS	AFSC	LOSAN	0	46	2.0
Norton AFB	MAC	NORTN	0	60	1.0
March AFB	SAC	MARCH	0	60	1.0
Indian Springs Aux Field	AFTAC	INDMT	8	60	0.83
Nellis AFB	TAC	NELLS	8	72	0.83
Hill AFB	AFLC	HILL	16	36	1.25
Luke AFB	TAC	LUKE	20	64	2.25
Williams AFB	ATC	WILMS	20	66	1.5
Davis-Monthan AFB	TAC	DAVIS	16	66	1.5
Offutt AFB	SAC	OFFUT	28	40	2.5
Lowery AFB	ATC	LOWRY	12	44	1.3
US Air Force Academy			16	36	1.2
Peterson AFB	SPACECMD	PETER	16	54	1.7
Kirtland AFB	MAC	KRTLD	10	50	1.12
Cannon AFB	TAC	CANON	16	70	1.75
Holloman AFB	TAC	HOLMN	10	72	1.2
McConnell AFB	SAC	MCCNL	28	57	2.75
Vance AFB	ATC	VANCE	28	60	2.75
Tinker AFB	AFLC	TINKR	31	58	3.0
Altus AFB	MAC	ALTUS	25	65	2.5
Shepard AFB	ATC	SHPRD	31	66	2.75
Reese AFB	ATC	REESE	18	70	2.5
Carswell AFB	SAC	CRSWL	40	58	3.25
Dyess AFB	SAC	DYESS	28	64	3.0
Goodfellow AFB	ATC	GDFLW	22	69	2.25
Laughlin AFB	ATC	LGHLN	20	78	2.5
Lackland AFB	ATC	LKLND	32	58	3.2
Kelly AFB	AFLC	KELLY	32	58	3.2
Randolph AFB	ATC	RNDPH	36	56	3.2
Brooks AFB	AFSC	BROOK	35	55	3.3
Bergstorm AFB	TAC	BSTRM	42	54	3.5

Minneapolis-St. Paul AFB	AFRES	MINNE	.28	30	2.25
Gen. Billy Mitchell Field AFB	AFRES	GENBM	29	28	2.35
Richards-Gerbaur AFB	AFRES	RCHRD	36	42	3.0
Whiteman AFB	SAC	WHTMN	40	38	3.0
Blytheville AFB	SAC	BLYTH	48	40	3.3
Little Rock AFB	MAC	LTLRK	51	43	3.6
Barksdale AFB	SAC	BARKS	5C	49	3.75
England AFB	TAC	ENGLD	56	49	4.0
New Orleans NAS	AFRES		64	49	5.0
OHare IAP	AFRES	OHARE	34	32	2.5
Chanute AFB	ATC	CHNTE	38	33	2.75
Scott AFB	MAC	SCOTT	38	36	3.0
K.I. Sawyer AFB	SAC	KISWR	33	25	2.0
Wurtsmith AFB	SAC	WURTS	30	27	1.8
Selfridge ANG	BANG	SLFRD	32	30	2.15
Grissom AFB	SAC	GRSSM	40	33	2.75
Arnold AFS	AFSC	ARNLD	52	38	3.25
Columbia AFB	ATC		50	42	3.5
Keesler AFB	ATC	KESLR	60	47	4.5
Maxwell AFB	AU	MAXWL	52	43	3.75
Gunter AFS	AU		52	43	3.75
Dobbins AFB	AFRES	DOBNS	52	40	3.25
Robbins AFB	AFLC	ROBIN	47	44	3.5
Moody AFB	TAC	MOODY	52	45	3.5
Hurlburt Field AFB	MAC	HRLBT	64	47	5.0
Eglin AFB	AFSC	EGLIN	64	47	5.0
Tyndall AFB	TAC	TYNDL	60	47	5.0
Macdill AFB	TAC	MACDL	56	50	4.25
Patrick AFB	AFSC	PTRCK	54	46	4.0
Homestead AFB	TAC	HMSTD	56	54	4.0
Shaw AFB	TAC	SHAW	48	42	3.25
Myrtle Beach AFB	TAC	MYRTL	48	43	3.5
Charleston AFB	MAC	CHRTN	48	43	3.5
Seymour Johnson AFB	TAC	SEYMR	45	41	3.4
Pope AFB	MAC	POPE	47	41	3.4
Youngstown Municipal AP	AFRES	YNGTN	36	30	2.15
Rickenbacker ANGB	ANG	RICKN	40	32	2.25
Wright-Patterson AFB	AFLC	WRGHT	44	34	2.5
Loring AFB	SAC	LORNG	36	20	2.35
Pease AFB	SAC	PEASE	42	25	2.52
Hanscom AFB	AFSC	HNSCM	44	27	2.5
Westover AFB	AFRES	WSTVR	45	27	2.5
Plattsburgh AFB	SAC	PLTSB	36	24	2.0
Griffiss AFB	SAC	GRFIS	44	26	2.2
Niagara Falls IAP	AFRES	NIGRA	32	27	2.1
Greater Pitts-burgh IAP	AFRES	PITTS	38	28	2.25

Willow Grove ARF	AFRES	WLWGR	48	34	2.55
McGuire AFB	MAC	MCGRE	44	32	2.55
Dover AFB	MAC	DOVER	45	35	2.6
Bolling AFB	MAC	BLLNG	42	37	2.65
Andrews AFB	MAC	ANDRW	43	38	2.65
Washington D.C. Hq USAF			41	36	2.65
Langley AFB	TAC	LNGLY	44	40	3.0
Eielson AFB	AAC	EILSN	12	*	*
Elmendorf AFB	AAC	ELMNF	24	*	*
Shemya AFB	AAC	SHEMA	27	*	*
Wheeler AFB	PACAF	WHELR	*	*	*
Hickman AFB	PACAF	HICKM	*	*	*

* No data available at this time.

APPENDIX F

LIST OF DATA REQUIRED
TO RUN DPM

04/17/89

LIST OF DATA REQUIRED TO RUN DPM

The following data are required to evaluate IRP sites using the DPM. These data should be highlighted in the reports or listed separately to facilitate the data collection/evaluation process. Units are provided for convenience.

1. Whether pollutants observed in surface water (Y/N)
2. Distance to nearest surface water (miles)
3. Net precipitation (inches)
4. Surface erosion potential (none/slight/moderate/severe)
5. Rainfall intensity - 1 year 24 hour peak (inches)
6. Surface permeability (cm or % clay)
7. Flooding potential (distance to 100 year and 25 year floodplains)
8. Waste containment effectiveness
9. Whether pollutants observed in ground water (Y/N)
10. Depth to seasonal high ground water from base of waste or contaminant zone (feet)
11. Permeability of unsaturated zone as measured by hydraulic conductivity (cm/sec)
12. Infiltration potential (function of waste form and net precipitation (in))
13. Potential for discrete features in unsaturated zone to "short circuit" the pathway to the water table (none/low/moderate/high)
14. Whether pollutants observed in ambient air (Y/N)
15. Whether volatile pollutants observed in soil (Y/N)
16. Average soil temperature (deg C)
17. Wind velocity (miles/hour)
18. Soil porosity (.10 to .40)
19. Days per year with >.25mm precipitation
20. Site activity level (none/occasional/moderate/heavy)
21. Population obtaining drinking water from surface water (size/distance)
22. Water use of nearest surface water body

23. Population within 1000 ft of site (size/distance)

24. Distance to nearest installation boundary (miles)

25. Land use or zoning (use/distance)

26. Importance of biota/habitats in potentially affected surface water bodies near the site

27. Importance of biota/habitats in potentially affected terrestrial areas near the site

28 Presence of critical environments within 1.5 miles of site (Y/N)

29. Estimated mean ground water travel time to nearest downgradient water supply well (years)

30. Estimated mean ground water travel time to nearest surface water body (years)

31. Population potentially at risk from ground water contamination (size/distance)

32. Estimated mean ground water travel time from waste location to any downgradient habitat or natural area (years)

33. Distance to sensitive habitats (miles)

34. Importance/sensitivity of downgradient biota/habitats that are near confirmed or suspected ground water discharge points

35. Importance/sensitivity of downgradient biota/habitats that are affected by surface water discharges

36. Pollutants identified in surface water and their concentrations

37. Pollutants identified in ground water and their concentrations

38. Pollutants identified in ambient air and their concentrations

39. Volatile pollutants identified in surface soil and their concentrations

40. Volatile pollutants identified in fugitive dust and their concentrations

APPENDIX G

USER'S MANUAL FOR THE AUTOMATED DPM (ADPM)

The AUTOMATED DEFENSE PRIORITY MODEL

(ADPM) USER'S MANUAL

Version 2.0

George K. Mikroudis, Ph.D.
Chidambaram Subramanian,
Judith M. Hushon, Ph.D.

April 1989

Prepared for
U.S.A.F Occupational and Environmental Health Laboratory
Brooks Air Force Base, Texas 78235

Prepared by
Roy F. Weston, Inc.
Washington, DC 20024

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PREFACE

The AUTOMATED DEFENSE Site Remediation PRIORITY MODEL ADPM, Version 2.0: USER'S MANUAL

A Hazard screening system known as the Defense Priority Model (DPM) was developed by the Oak Ridge National Laboratory and used to identify sites containing hazardous waste and to rank these sites with respect to their potential environmental hazard. Weston has developed an automated version and an extension of the DPM model referred to as the "Automated DPM" (ADPM), which is intended to be used in prioritizing Department of Defense hazardous waste sites for remediation actions.

This manual describes how to use each of the elements of ADPM, version 2.0, an automated version of DPM with expert system enhancements. The manual includes instructions suitable for a novice user and operation hints. It is divided into four chapters:

Chapter 1	This chapter describes how to install ADPM, how to run ADPM, and how to get to the main ADPM menu.
Chapter 2	This chapter describes how to use each of the elements of the ADPM menu. It provides an overview of a site evaluation process through the use of an example. It shows how to answer the ADPM questions, make changes to the data, and print, and/or save the results.
Chapter 3	This chapter describes each one of the ADPM menu options. It also explains other features of ADPM, such as the confidence scale, that can be applied during a site evaluation.
Chapter 4	This chapter describes how to prepare a file of input data for ADPM and how to add/modify its databases of chemical information and on-line explanations (for advanced users).

Chapter 1

INSTALLATION

The files for the ADPM system are contained on two diskettes. The installation procedures are as follows (the user's input is underlined):

1. You should make backup copies of the ADPM diskettes. Use the MS-DOS <u>diskcopy</u> command to copy the source files. The backup copies should be used for the installation procedure. Store the original ADPM diskettes in a cool, dry place.

2. The ADPM files should be placed in a separate directory on the hard disk. You may want to create a new directory in which to store the ADPM files. For example, you could make the directory named <u>adpm</u> by typing:

   C><u>md</u> <u>adpm</u>

   Then, to change to that directory (in which you are going to place the source files) you should type:

   C><u>cd</u> <u>adpm</u>

3. Place the diskette containing the ADPM file in (top) floppy drive A. Copy the ADPM files to the hard disk by typing:

   C><u>copy</u> <u>a:*.*</u>

   Repeat the command with the the other diskette.

1.1 ADPM system requirements

Running ADPM requires an IBM compatible PC with at least 640 kilobytes of RAM. Also, ADPM will open a number of files, so it is recommended to set your MS-DOS system's open file limit to 20. To do this you place the following file specification in your <u>config.sys</u> file:

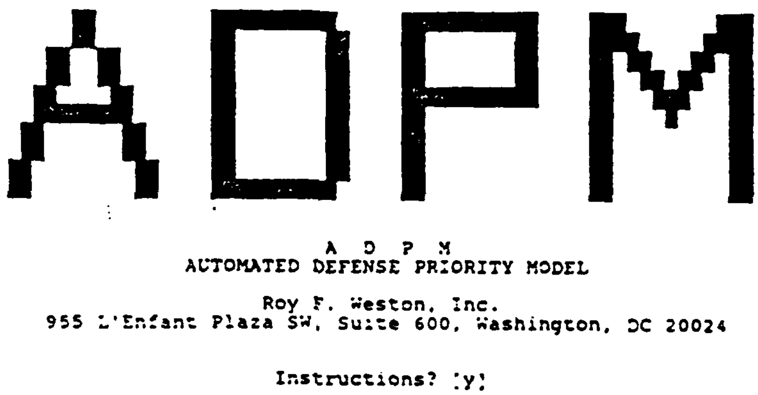
    files=20

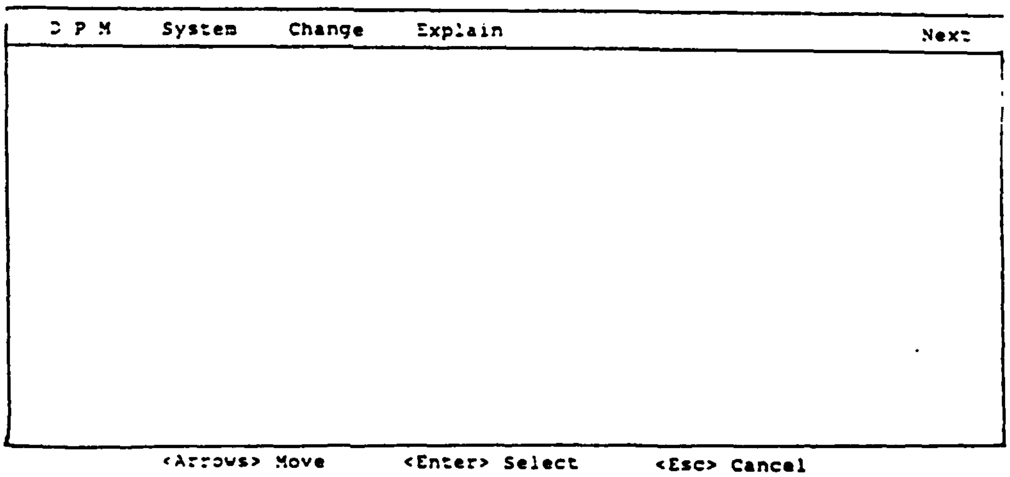
1.2 Starting ADPM

Once you have completed the installation procedure you are ready to run ADPM. First, make sure you are in the directory that contains the ADPM files. To start ADPM, type:

C>adpm

After a few seconds, the ADPM logo will appear. The system displays short messages at the last line of the screen while its databases are being loaded. When this is completed you will be asked if you want to read some brief instructions. Press y if you wish to see the instructions. Touch any other key and then the ADPM main menu will appear. Chapters 2 and 3 describe how to use each of the main menu options.





1.3 Exiting ADPM

You can exit ADPM by selecting the System option from the main menu and then choosing Quit (you can do so by pressing sq).

```
  D P M     System     Change     Explain                         Next
            Comments, Options
            Retrieve Data File
            Save as File
            Print Data
            Quit

            <Arrows> Move      <Enter> Select      <Esc> Cancel
```

You will see the following screen. Press y if you wish to exit the program. Pressing any other key will return you to the main menu.

```
  D P M     System     Change     Explain                         Next
 QUIT

                         Quit ADPM? (y)

            <y> Quit ADPM    <Any key> Return to main menu
```

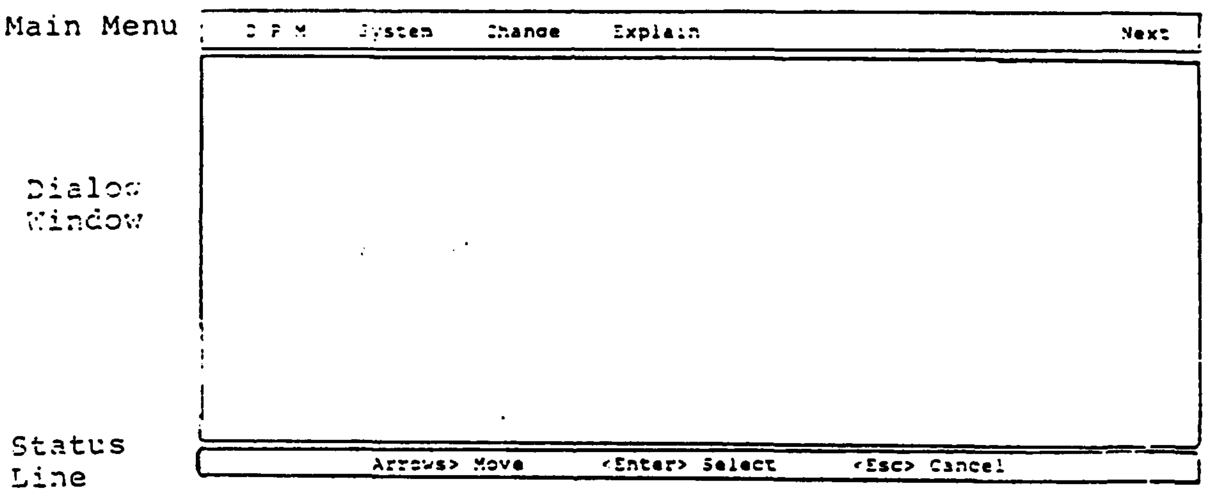
Chapter 2

THE ADPM MENU

If you have not already started ADPM, do so by typing:

C>adpm

Then, after the ADPM logo is displayed and some (optional) instructions you will see the following:



When you start ADPM the cursor is placed in the **Main Menu**.The menu bar appears at the top of the screen. Below the main menu is the **Dialog window** in which ADPM will ask questions, you may provide answers, and ADPM can display results. The bottom line of the screen is the **Status Line** that displays other options available to you besides the ones which can be selected from the windows above.

The following basic procedures are helpful for moving among the various elements of ADPM:

Menu - window Use the arrow keys to move the cursor and press <Enter> to select a menu option. The option executes and moves you to the dialog window. While in the dialog window press the <Esc> key.

	This will exit the dialog window and you will return to the Main Menu.
Exit ADPM	Select System from the Main Menu and choose Quit. You will be prompted to save your data and then asked: "Quit ADPM? [y]". Press y if you really want to quit. Pressing any other key will return you to the Main Menu.
Explanation	Press the <F1> function key. This will rephrase the current question, and provide more details explaining the DPM factor and the types of data needed for the evaluation.
Confidence	When you are asked for data to ADPM questions you may not feel confident about your answer. Press the <F2> function key and you will be prompted to enter a number that indicates your confidence in a confidence scale of 0 (uncertain) to 1 (certain).
Units	Certain ADPM questions require answers expressed in specific base units, e.g. distance, in feet. In that case the base units are displayed at the prompt. If you wish to use different units, e.g. meters, enter your answer and the cursor will be placed over the units display. Press the <Up> or <Down> arrow keys and other available units will be displayed. When your desired units are displayed, press <Enter> to make the selection.

In general, pressing the <Esc> key will exit the current action of ADPM pressing <Enter> will continue and pressing the <F1> key will give you an explanation.

2.1 Moving Around and Making Selections

To move from the Main Menu to another section of ADPM you need to select the menu option corresponding to that section. Pressing <Enter> will move you to the Defense Priority Model (DPM) evaluation. While in the DPM section you will be asked questions in the Dialog Window. Most of these questions require an answer. After typing an answer press the <Enter> key. In some cases, ADPM has alternative ways of determining the value of a DPM factor, so it may not necessarily need an answer. Pressing the <Enter> key instead, is equivalent to answering "unknown" to the current question and DPM will go on with an alternate question. If pressing the <Enter> key does not move to another question that means that there are no alternates and the current question needs an answer for the evaluation to proceed. The ADPM prompt shows you (inside its square brackets) what are the acceptable answers. The answers could be one of the following types:

Choice	For example, [1,2,3]. In this case, ADPM will accept only the numbers 1,2, or 3.
Positive number	ADPM will accept only positive numbers. If you type something else (e.g, -3, or text) the answer will not be accepted and the cursor will remain at the current ADPM prompt.
Number	Numbers are acceptable but text is not
Text	Any answer (text or numbers) is acceptable

When the menu bar is displayed, you can move the cursor back and forth among the items in the menu. For each item on the menu there is an associated pull-down menu of selection items. These items are not displayed and you cannot select them yet. Press the <Alt> key. When you move from item to item in the menu bar the associated pull-down menus are automatically displayed. When these items are displayed you can move to an item using the arrow keys and make a selection. Besides the <Alt> key you can use the Down-arrow key to switch to the pull-down menu.

When in the pull-down menu, you can move from among items or from one pull-down menu to another, or make a menu selection.

<Right-arrow>	Moves the cursor one menu bar item to the right. The pull-down menu associated with the menu bar is displayed. If the cursor is at the last item in the menu bar, the pressing the Right-arrow key moves to the first item in the menu bar.
<Left-arrow>	Moves the cursor one menu bar item to the left. The pull-down menu associated with the menu bar item is displayed. If the cursor is at the last item in the menu bar, the pressing the Right-arrow key moves to the last item in the menu bar.
<Up-arrow>	Moves the cursor up one item in the pull-down menu. If the cursor is at the first option in the pull-down menu, pressing the Up-arrow key moves the cursor to the last item in the pull-down menu.
<Down-arrow>	Moves the cursor down one item in the pull-down menu. If the cursor is at the last option in the pull-down menu, pressing the Up-arrow key moves the cursor to the first item in the pull-down menu.
<Enter>	Selects the menu item at which the cursor is placed and exits the menu.
<Alt>	Switches to the menu bar.

<Esc> Exits the menu.

In addition to moving to an item through the use of an arrow key, you can move to a menu item through the use of an accelerator key. An accelerator key is a key that is associated with a particular menu item so that the item can be chosen by pressing the key. If a menu item is associated with an accelerator key, then the character representing the accelerator key appears in a different color (in monochrome displays is underlined).

```
 D P M    System    Change  | Explain |                          Next
 Q U I T                    | Surface Water Pathways            |
                            | Groundwater Pathways              |
                            | Air Pathways                      |
                            |-----------------------------------|
                            | Surface Water Hazard              |
                            | Groundwater Hazard                |
                            | Air Hazard A                      |
                            | Air Hazard B                      |
                            |-----------------------------------|
                            | Surface Water Health Receptors    |
                            | Surface Water Ecological Receptors|
                            | Groundwater Health Receptors      |
                            | Groundwater Ecological Receptors  |
                            | Air Health Receptors              |
                            | Air Ecological Receptors          |

            <Arrows> Move     <Enter> Select     <Esc> Cancel
```

2.2 Using ADPM

The next two chapters describe everything you need to know to use ADPM. This chapter guides you through a typical ADPM session. This guided tour of ADPM covers the different sections of the system and serves as an example of how to use the system. Finally, the following chapter describes each one of the options of ADPM in detail.

Before going through the ADPM session we give some general operation hints. The objective of a consultation is to obtain a site rating using the Defense Priority Model, (DPM). The various options of ADPM are designed to assist a user in such an evaluation.

There are three different ways of providing input data to ADPM: (1) through a data file, (2) by answering ADPM questions, and (3) by "changing" the values of DPM factors. These routines will be explained in the following. Each one is activated by a different ADPM menu option as follows:

DPM	You are prompted to answer questions for each of the DPM factors where data is needed in order to obtain an overall rating of the site.
Change	You can selectively change the values of any DPM factor for which data has been provided.
Import data	You can specify a file that contains previously saved data. Such files are ASCII files normally created by ADPM when you chose to save a session. You may chose to modify an existing file or create a new such file of the same format using any text editor. This file can subsequently be used as input file to ADPM.

When ADPM asks you a question, it checks your answer whether it is an acceptable one for the question. The <F1> and <F2> keys are acceptable; they display a menu with a further explanation of the question and a prompt for a confidence level, respectively. The <Esc> key is also acceptable but pressing this key exits the question and returns you to the Main Menu. The legal answers or the type of required input (e.g. text or numbers) is indicated inside the ADPM prompt. Finally, if ADPM has an alternate question for the current factor it accepts as an answer the <Enter> key and proceeds with the alternate question.

2.3 A Sample Session

From the MS-DOS directory where you installed the ADPM files, start ADPM by typing:

C>adpm

This will take a few seconds since ADPM is loading the main program and the databases. The ADPM logo appears while the status window is displaying short messages as each part of the system is being loaded. Type y and you will see the following screen. Touching any key will take you to the Main Menu.

```
ADPM

A D P M
AUTOMATED DEFENSE PRIORITY MODEL

Roy F. Weston, Inc.
955 L'Enfant Plaza SW, Suite 600, Washington, DC 20024

Instructions? [Y]
```

```
A D P M

ADPM, version 2.0, is an automated version of the Defense
Priority Model (DPM) which is used by the US Air Force
for prioritization of hazardous waste sites for remedial
action.

In the following, you will be asked to provide site information
and input data required for the application of DPM.  If you
do not understand a question you may press the <F1> function key
for an explanation.  If you do not know an answer press the
<Enter> key for a (possibly), alternate question.  If you are
not confident about your input you may press the <F2> key
and you will be prompted to enter a confidence level.  Press the
<Escape> key if you wish to exit any part of the program.

Intermediate calculations are displayed at the top of the screen.
Acceptable answers to questions will be shown at the prompt.
The last line of the screen will display additional options.

Press any key to continue
```

A typical session may start by consulting a file with previously saved data (i.e., from an earlier site evaluation). Select System from the Main Menu and choose the Retrieve Data File option.

```
  D P M    System   Change    Explain                                Next

- Q U I T    Comments, Options

             Retrieve Data File
             Save as File
             Print Data

             Quit

         <Arrows> Move       <Enter> Select       <Esc> Cancel
```

You will see the following screen. Type a name of a file that contains previously saved data. (Your ADPM diskettes contain one such file called adpm.dat, to be used as an example).

```
  D P M    System    Change    Explain                               Next

 R E T R I E V E   D A T A
 Filename for data input  (*.*) *

                         <Enter> Return to main menu
```

Now the input file has been consulted and ADPM has data to start a site evaluation. Press <Enter><Enter> to select DPM from the Main Menu. This activates the DPM decision logic and the site evaluation begins. When a factor score is calculated it is displayed at the top of the screen in place of the Main Menu. If all the data are known, the scores are displayed one after the other and are summarized for each DPM scoring category, such as Surface Water Pathways. Press any key to move on to the next category. Finally, in the last category, the Dialog Window shows the site evaluation results as follows:

```
OVERALL SITE SCORE
                                S U M M A R Y

A. Installation :  Luke AFB
B. Site name    :  North FTA
C. Location     :  Luke AFB
D. Reviewer     :  Chid Subramanian
E. Date         :  Wednesday, May 31, 1989

 [12] Final score for surface water pathways ([10] x [11])              18.33
 [22] Final score for groundwater pathways ([20] x [21])                59.65
 [35] Final score for air/soil pathway ([34] x [33])                    80.56
 [43] Normalized health hazard index -- sw ([42] x 100/9)               33.33
 [45] Normalized ecological hazard index -- sw ([44] x 100/6)           33.33
 [53] Normalized health hazard index -- gw ([52] x 100/9)               33.33
 [55] Normalized ecological hazard index -- gw ([54] x 100/6)           33.33
 [58] Normalized human health hazard score --air ([57] x 100/6)         100.0
 [61] Normalized ecological hazard score -- air ([50] x 100/6)          50.0
 [72] Final score for human health receptors -- sw ([71] x 100/27)      22.22
 [76] Final score for ecological receptors -- sw ([75] x 100/18)        55.56
 [84] Final score for human health receptors -- gw ([83] x 100/96)      43.75
 [89] Final score for ecological receptors -- gw ([88] x 100/21)        28.57
 [94] Final score for ecological receptors -- gw ([93] x 100/39)        66.67
 [98] Final score for ecological receptors on air pathways ([97] x 10066.67
 [106] Overall site score ([105] / 4.24)                                29.41

            <Arrows> Move        <Enter> Select        <Esc> Cancel
```

Supposing now that you wish to evaluate a new site. Select Next from the Main Menu. ADPM prompts you first for a file name to save the session. Press <Enter> if you do not wish to save your data; the old data will be erased. After saving the old data ADPM is ready for a new site.

```
  D P M    System    Change    Explain                           Next

 N E X T
                   Database will be erased... Save your data
Filename for saving data (*.*) ▸

                 <Enter> Return to main menu
```

```
  D P M    System    Change    Explain                           Next

 N E X T
                   Database will be erased... Save your data
Filename for saving data (*.*) ▸
Clearing database...   READY FOR NEXT SITE.

        <Arrows> Move      <Enter> Select      <Esc> Cancel
```

Press <Enter><Enter> to select DPM and start a new site evaluation. First, you will be asked four questions that will help identify the site. The answer to your first question, Installation, is also used to match the installation name to a name of a major US Air Force facility for which climatic information is known to ADPM. The names of US Air Force facilities are displayed in the ID column of Appendix.E. So the system will automatically access the stored meteorological data. If a match is found in ADPM's climatic information database then the value of these factors, such as precipitation and rainfall, will be automatically supplied by the program.

```
   D P M     System     Change     Explain                              Next
 - SITE IDENTIFICATION ---------------------------------------------------
 Date: Wednesday, September 28, 1988                 Time: 9:36

 A. Installation  •



 <Enter> Continue  <F1> Explanation   <Esc> Main Menu
```

The next question, Site name, identifies uniquely the rated site and your answer is used as a heading when displaying site evaluation results. The remaining questions, Location and Reviewer, serve documentation purposes.

```
   D P M     System     Change     Explain                              Next
 - SITE IDENTIFICATION ---------------------------------------------------
 Date: Wednesday, September 28, 1988                 Time: 9:36

 A. Installation   • McGuire AFB
 B. Site name      • Area Spill #2
 C. Location       • Myrtle Beach, SC
 D. Reviewer       • GKM



 <Enter> Continue  <F1> Explanation   <Esc> Main Menu
```

The actual site evaluation begins now. The first section of a DPM rating is evaluating the Surface Water Pathways. The first question looks as follows:

```
                              SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[1] Observed releases in surface water
- SURFACE WATER PATHWAYS ------------------------------------------------

Have contaminants been detected in surface water?

1.      yes
          Must be based on: (I) at least one analytical determination
          in which contaminants were present in surface water at a level
          that represents a significant increase above background,
          AND, (II) an indication that the contaminants migrated from the
          rated site via surface water transport routes

2.      no
(If contaminants are equally likely to have come from several sources
select "no" and note the reason for this in the Comments.)

[ 1 2 ]▸

-------------------------------------------------------------------------
        <F1> Explain    <F2> Confidence scale    <Esc> Main menu
```

Press the F1 key to get a further explanation on the question. You will see the following screen. Read the explanation and press any key to return to the question.

```
- FACTOR: [1] Observed releases in surface water ---------------------

Observed releases [1]:
A finding that contaminants have been detected must be based on
(1) at least one analytical determination in which contaminants were
present in surface water at a level that represents a significant (in
terms of demonstrating that contamination has occurred, not in terms of
potential effects) increase above background, and

(2) an indication (e.g., due to physical locations
and/or nature of contaminants) that the
contaminants migrated from the rated site via surface transport routes.

If only one of several analyses indicated contamination and there is a
good reason to suspect the validity of the analytical result, assign a
score of zero and note the reason for this score in the "Comments".
If contaminants detected in surface waters
are equally likely to have come from several sources, assign a score of
zero and note the reason for this score in the "Comments".

-----------------------------------------------------------------------
                       Press any key to continue
```

If you do not feel confident for an answer press the <F2> key. You are prompted to enter your confidence level. The confidence level corresponds to a "confidence scale" of 0 to 1. A confidence level of 1 has the meaning of absolute certainty, whereas a confidence level of 0 has the meaning of absolutely not certain. Confidence levels between 1 and 0 indicate some degree of certainty with 0.5 meaning that there is more certainty of truth than there is of not truth. The use of the confidence scale does not affect the site rating but is used as an indication of the relative confidence of the rater to the ADPM questions. Enter <u>0.9</u> as your confidence level. The cursor will move back to the space for answering the question. Notice that if you wish to give a confidence level you must do that first (by pressing the <F2> key) and then provide your answer. If you give an answer first, ADPM will assume a confidence level of 1 and will proceed to the next question.

```
                              SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
[1] Observed releases in surface water
┌ SURFACE WATER PATHWAYS ─────────────────────────────────────────────────────┐
│                                                                             │
│Have contaminants been detected in surface water?                            │
│                                                                             │
│1.       yes                                                                 │
│           Must be based on: (I) at least one analytical determination       │
│           in which contaminants were present in surface water at a level    │
│           that represents a significant increase above background,          │
│           AND, (II) an indication that the contaminants migrated from the   │
│           rated site via surface water transport routes                     │
│                                                                             │
│2.       no                                                                  │
│(If contaminants are equally likely to have come from several sources       │
│select "no" and note the reason for this in the Comments.)                   │
│                                                                             │
│[ 1 2 ]»                                           Conf[0-1]» 0.9            │
│                                                                             │
└─────────────────────────────────────────────────────────────────────────────┘
            <F1> Explain    <F2> Confidence scale    <Esc> Main menu
```

Enter 2 as an answer. A pop-up window appears at the bottom of the screen prompting you for a comment. For every ADPM factor you will be asked to provide some comments as well, which are used to document your answers.

```
                              SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[1] Observed releases in surface water
- SURFACE WATER PATHWAYS ---------------------------------------------------

Have contaminants been detected in surface water?

1.       yes
           Must be based on: (I) at least one analytical determination
           in which contaminants were present in surface water at a level
           that represents a significant increase above background,
           AND, (II) an indication that the contaminants migrated from the
           rated site via surface water transport routes

2.       no
(If contaminants are equally likely to have come from several sources
select "no" and note the reason for this in the Comments.)

[ 1 2 ]> 2                                      Conf[0-1]> 0.9

----------------------------------------------------------------------------
          <F1> Explain    <F2> Confidence scale    <Esc> Main menu
```

Type in a comment. The comment can extend as many lines as you wish. You may edit each line as you type it, but you cannot move back and edit a previous line. Use carriage returns to go to a new line. When finished, press <Enter> to continue.

```
                              SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[1] Observed releases in surface water
- SURFACE WATER PATHWAYS ---------------------------------------------------

Have contaminants been detected in surface water?

1.       yes
           Must be based on: (I) at least one analytical determination
           in which contaminants were present in surface water at a level
           that represents a significant increase above background,
           AND, (II) an indication that the contaminants migrated from the
- C O M M E N T ------------------------------------------------------------
               [1] Observed releases in surface water = no

Comment [text]>
Data were scanty...
Assumed no release.

----------------------------------------------------------------------------
                              <Enter> Continue
```

ADPM moves on to the next question. Notice that the DPM score was calculated for "Observed releases in surface water" and is displayed at the top window. The new question is about distance to the nearest surface water. This distance must be in units of feet and this is indicated after the prompt.

```
                              SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
(2) Distance to nearest surface water
┌ SURFACE WATER PATHWAYS ──────────────────────────────────────────────────────┐
│                                                                              │
│What is the distance to the nearest surface water?                            │
│                                                                              │
│( positive number )•               feet                                       │
│                                                                              │
│                                                                              │
└──────────────────────────────────────────────────────────────────────────────┘
          <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

ADPM will automatically convert different units to feet. Enter 1 and the cursor moves over to the units. Press the <Down> or <Up> arrow keys and you will see different units beeing displayed, i.e., meters, miles, kilometers, and units(feet). When you have miles displayed press <Enter> to make this selection.

```
                              SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
(2) Distance to nearest surface water
┌ SURFACE WATER PATHWAYS ──────────────────────────────────────────────────────┐
│                                                                              │
│What is the distance to the nearest surface water?                            │
│                                                                              │
│( positive number )• 1             miles                                      │
│                                                                              │
│                                                                              │
└──────────────────────────────────────────────────────────────────────────────┘
       <Down-Arrow> or <Up-Arrow> Change units    <Enter> Select
```

You will be prompted again to enter a comment to document your answer. Type in your comment and press <Enter> to continue.

```
                              SITE: Area Spill #2
D S R P M   factor                                            SCORE   RESULT
[2] Distance to nearest surface water
┌ SURFACE WATER PATHWAYS ──────────────────────────────────────────────────┐
│                                                                          │
│What is the distance to the nearest surface water?                        │
│                                                                          │
│[ positive number ]▸ 1              miles                                 │
│                                                                          │
│                                                                          │
┌ C O M M E N T ───────────────────────────────────────────────────────────┐
│          [2] Distance to nearest surface water (feet) = 5249.30          │
│                                                                          │
│Comment [text]▸                                                           │
│                                                                          │
│                                                                          │
└──────────────────────────────────────────────────────────────────────────┘
                              <Enter> Continue
```

```
                              SITE: Area Spill #2
D S R P M   factor                                            SCORE   RESULT
[2] Distance to nearest surface water
┌ SURFACE WATER PATHWAYS ──────────────────────────────────────────────────┐
│                                                                          │
│What is the distance to the nearest surface water?                        │
│                                                                          │
│[ positive number ]▸ 1              miles                                 │
│                                                                          │
│                                                                          │
┌ C O M M E N T ───────────────────────────────────────────────────────────┐
│          [2] Distance to nearest surface water (feet) = 5249.30          │
│                                                                          │
│Comment [text]▸                                                           │
│Distance obtained from report, pp.123.                                    │
│                                                                          │
│                                                                          │
└──────────────────────────────────────────────────────────────────────────┘
                              <Enter> Continue
```

The next question is about net precipitation. Press <Enter>. You will see that <Enter> is accepted and another question appears about annual precipitation. When ADPM has an alternate way of calculating a score it accepts <Enter> and displays the alternate question.

```
                              SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[3] Net precipitation
┌ SURFACE WATER PATHWAYS ─────────────────────────────────────────────────┐
│                                                                          │
│What is the net precipitation?                                            │
│                                                                          │
│[ number ]•                           inches                              │
│                                                                          │
│What is the average annual precipitation?                                 │
│                                                                          │
│[ positive number ]•                  inches                              │
│                                                                          │
└──────────────────────────────────────────────────────────────────────────┘
  <Enter> Estimate   <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

Press <Enter> again and a pop-up window at the bottom of the screen shows that ADPM automatically assigns a value for annual precipitation. This value was found from the climate database based on the name of the US Air Force installation, McGuire AFB.

```
                              SITE: Area Spill #2
D S R P M   factor
[3] Net precipitation                                       SCORE   RESULT
┌ SURFACE WATER PATHWAYS ─────────────────────────────────────────────────┐
│                                                                          │
│What is the net precipitation?                                            │
│                                                                          │
│[ number ]•                           inches                              │
│                                                                          │
│What is the average annual precipitation?                                 │
│                                                                          │
│[ positive number ]•                  inches                              │
│                                                                          │
│ ┌ Annual precipitation estimate ────────────────────────────────────────┐│
│ │Normal annual total precipitation estimated from Figure 2, ADPM Manual.││
│ │Installation:        McGuire AFB                                       ││
│ │Annual Precipitation: 44.0 inches                                      ││
└─└───────────────────────────────────────────────────────────────────────┘┘
                          Press any key to continue
```

Press any key to continue and you will be prompted to enter a comment for the annual precipitation. Although this value was automatically assigned by the program, you are still propted for a comment to document this factor.

```
                         SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[3] Net precipitation
- SURFACE WATER PATHWAYS ----------------------------------------------------

What is the net precipitation?

[ number ]>                           inches

What is the average annual precipitation?

[ positive number ]>                  inches
- C O M M E N T -------------------------------------------------------------
         [3b] Average annual precipitation (inches) = 44

Comment [text]>
From program's database

-----------------------------------------------------------------------------
                         <Enter> Continue
```

Enter a comment and press <Enter> to continue. The next question is about lake evaporation. Press <Enter> again and ADPM will find the value of annual lake evaporation and display it in a pop-up window at the bottom of the screen.

```
                         SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[3] Net precipitation
- SURFACE WATER PATHWAYS ----------------------------------------------------

What is the net precipitation?

[ number ]>                           inches

What is the average annual precipitation?

[ positive number ]>                  inches

What is average annual lake evaporation?

[ positive number ]>                  inches

-----------------------------------------------------------------------------
  <Enter> Estimate   <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

Press any key to continue and you will be prompted to enter comments for lake evaporation as well as for net precipitation. ADPM calculates the net precipitation and displays a note in a pop-up window above the Status Line. The value of net precipitation was found by the program (precipitation - evaporation), but it also needs documentation in the comments window.

```
                         SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
[3] Net precipitation
- SURFACE WATER PATHWAYS

 What is the net precipitation?

 [ number ]•                          inches

 What is the average annual precipitation?

 [ positive number ]•                 inches
 C O M M E N T
                [3c] Average annual evaporation (inches) = 32

 Comment [text]•
 From program's database

                         <Enter> Continue
```

```
                         SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
[3] Net precipitation
 SURFACE WATER PATHWAYS

 What is the net precipitation?

 [ number ]•                          inches

 What is the average annual precipitation?

 [ positive number ]•                 inches

 What is average annual lake evaporation?

 [ positive number ]•                 inches

   N O T E

  ESTIMATED VALUE:
  [3a] Net precipitation (inches) = 12.0

                       Press any key to continue
```

At this point, we are going to disable the comments prompt so that we can proceed with scoring faster. Press <Esc> to return to the Main Menu. Then, press s followed by a c to select the Comments option (from the System menu). You will see the following:

```
  D P M     System     Change     Explain                    Next
 SURFACE    Comments, Options
            Retrieve Data File  S U M M A R Y
A. Instal   Print Data
B. Site n                       :
C. Locati   Quit                , SC
D. Review
E. Date          :   Wednesday, September 28, 1988

        <Arrows> Move      <Enter> Select      <Esc> Cancel
```

Press any key to de-activate the comments. (Pressing y is used to activate this option).

```
  D P M     System     Change     Explain                    Next
 O P T I O N S
 Comments prompting?           [Y]

        <Y> Comments ON    <Any key> Comments OFF
```

Now press <Enter><Enter> to continue the evaluation. You will see the question about surface erosion potential in the Dialog Window and the current DPM score at the top window.

```
                         SITE: Area Spill #2

D S R P M   factor                                      SCORE   RESULT
[4] Surface erosion potential
- SURFACE WATER PATHWAYS ------------------------------------------------

What is the surface erosion potential?

1.      none
2.      slight
3.      moderate
4.      severe

[ 1 2 3 4 ]>                                   Conf[0-1]> 0.8

-------------------------------------------------------------------------
          A number between 0 (NOT Certain) and 1 (Certain)
```

Press <F2> to give a confidence level, e.g. 0.8, and then answer the question.

The next question is about **rainfall intensity**. At any point in the ADPM session you may want to go back and change your answers to previous questions. Press <Esc> to exit to the Main Menu.

```
                              SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[5] Rainfall intensity
- SURFACE WATER PATHWAYS ---------------------------------------------------

 What is the 1-year 24-hour rainfall intensity?

 [ positive number ]                  inches

----------------------------------------------------------------------------
 <Enter> Estimate   <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

Press c to select the Change option from the Main Menu. A pull-down menu displays the DPM scoring categories.

```
  D P M      System  | Change | Explain                              Next
 Q U I T ----------  General Site Information

                     Surface Water Pathways
                     Air Pathways
                     Groundwater Pathways

                     Surface Water Hazard
                     Groundwater Hazard
                     Air Hazard

                     Surface Water Human Health Receptors
                     Surface Water Ecological Receptors

                     Air Human Health Receptors
                     Air Ecological Receptors

                     Groundwater Human Health Receptors
                     Groundwater Ecological Receptors

            <Arrows> Move      <Enter> Select      <Esc> Cancel
```

Select one category to change, e.g. **Surface Water Pathways**. You will see a listing of the known Surface Water Pathways factors and their values. Press the Down-Arrow to move to the item you want to change, for example, **erosion potential**. Press <Enter> to select this item.

```
                     Surface Water Pathways

[1] Observed releases in surface water = no
[2] Distance to nearest surface water (feet) = 5249.30
[3a] Net precipitation (inches) = 12
[3b] Average annual precipitation (inches) = 44
[3c] Average annual evaporation (inches) = 32
[4a] Surface erosion potential = slight

      <Up- Down- arrows> Move    <Enter> Select    <Esc> Main Menu
```

ADPM is asking you again the question to determine erosion potential. Answer the question.

```
                     Surface Water Pathways
[1] Observed releases in surface water = no
 CHANGE (ERASED: [4a] Surface erosion potential)

What is the surface erosion potential?

1.      none
2.      slight
3.      moderate
4.      severe

[ 1 2 3 4 ]= 3                                  Conf[0-1]= 0.8

      <F1> Explain    <F2> Confidence scale    <Esc> Main menu
```

Notice what happened after your response. The Main Menu at the top of the screen is gone and is replaced by the score calculated for this factor, erosion potential. Also, the cursor is positioned back again in the "Change menu" so that you may continue with more changes.

```
                         Surface Water Pathways

[1] Observed releases in surface water = no
[2] Distance to nearest surface water (feet) = 5249.30
[3a] Net precipitation (inches) = 12
[3b] Average annual precipitation (inches) = 44
[3c] Average annual evaporation (inches) = 32
[4a] Surface erosion potential = moderate

<Up- Down- arrows> Move    <Enter> Select    <Esc> Main Menu
```

Press <Esc> to leave the Change menu. ADPM will attempt to re-evaluate the site so it will come again to the question about rainfall intensity. Press <Esc> to return to the main menu. Then press <Enter><Enter> to continue the evaluation.

```
                         SITE: Area Spill #2
D S R P M   factor                                       SCORE   RESULT
[5] Rainfall intensity
- SURFACE WATER PATHWAYS

What is the 1-year 24-hour rainfall intensity?

( positive number )•              inches

<Enter> Estimate   <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

The question about rainfall intensity comes up again. Press <Enter> and ADPM will retrieve the answer from its climate database.

```
                          SITE: Area Spill #2
D S R P M   factor                                    SCORE   RESULT
[5] Rainfall intensity
- SURFACE WATER PATHWAYS

What is the 1-year 24-hour rainfall intensity?

[ positive number ]•                inches


<Enter> Estimate   <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

A pop-up window shows you the data that was retrieved from the database. Press any key to continue.

```
                          SITE: Area Spill #2
D S R P M   factor                                    SCORE   RESULT
[5] Rainfall intensity
- SURFACE WATER PATHWAYS

What is the 1-year 24-hour rainfall intensity?

[ positive number ]•                inches

 Rainfall intensity estimate
 Normal rainfall intensity estimated from Figure 4, ADPM Manual.
 Installation:      McGuire AFB
 Rainfall Intensity: 2.55 inches

                    Press any key to continue
```

The next question is about Unsaturated zone permeability. The Status Line indicates that you may press <Enter> for an estimate if the permeability is unknown. Press <Enter> and an alternate question appears to help you estimate the permeability.

```
                              SITE: Area Spill #2
D S R P M   factor                                                 SCORE   RESULT
[6] Surface permeability
- SURFACE WATER PATHWAYS ------------------------------------------------------

What is the surface soil permeability based on field/laboratory measurements?
(The presence of any engineered containment structures that modify
surface permeability should not be considered in evaluating this factor.)

[ positive number ]•              cm/sec

What is the clay content of the surface soils?

1.      Less than 15% clay.
2.      Between 15% to 30% clay.
3.      Between 30% to 50% clay.
4.      More than 50% clay.

[ 1 2 3 4 ]•

-------------------------------------------------------------------------------
        <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

The permeability now can be estimated based on the clay content of the site. Make a selection and ADPM estimates the permeability and displays the estimate at the pop-up window above the Status Line.

```
                              SITE: Area Spill #2
D S R P M   factor                                                 SCORE   RESULT
[6] Surface permeability
- SURFACE WATER PATHWAYS ------------------------------------------------------

What is the surface soil permeability based on field/laboratory measurements?
(The presence of any engineered containment structures that modify
surface permeability should not be considered in evaluating this factor.)

[ positive number ]•              cm/sec

What is the clay content of the surface soils?

1.      Less than 15% clay.
2.      Between 15% to 30% clay.
3.      Between 30% to 50% clay.
4.      More than 50% clay.
 - Surface permeability estimate ---------------------------------------------
[
 Based on clay content it is assumed:
 Surface permeability = 0.001 cm/sec

-------------------------------------------------------------------------------
                        Press any key to continue
```

Continue answering the questions until the Surface Water Pathways evaluation is completed. At that point you will see a summary of the DPM factors and their scores as follows:

Surface Water Pathways

SITE: Area Spill #2

D S R P M factor	SCORE	RESULT
[1] Observed releases in surface water	0	0
[2] Distance to nearest surface water	1.0	4.0
[3] Net precipitation	2.0	2.0
[4] Surface erosion potential	2.0	8.0
[5] Rainfall intensity	2.0	8.0
[6] Surface permeability	1.0	3.0
[7] Sum of items 2 through 6		25.0
[8] Normalized score ([7] x 100/48)		52.08
[9] Flooding potential	0	0
[10] Adjusted surface water pathways score (sum 8,9 or 100)		52.08
[11] Waste containment effectiveness factor for surface water	0.1	0.1
[12] Final score for surface water pathways ([10] x [11])		5.21

<Any key> Continue <F2> Confidence levels <Esc> Exit

Press <F2> and you will see a summary of the corresponding confidence levels. Notice that ADPM assigned confidence levels to all the factors even though you only gave numbers for two of the factors. ADPM assumed a confidence level of 1 for those questions that you did not supply your own. For those factors that were obtained by combining other factor scores, ADPM assigned the minimum of the confidence levels of the combining factors.

Surface Water Pathways

SITE: Area Spill #2

D S R P M factor	Conf.	RESULT
[1] Observed releases in surface water	0.9	0
[2] Distance to nearest surface water	1	4.0
[3] Net precipitation	1	2.0
[4] Surface erosion potential	0.8	8.0
[5] Rainfall intensity	1	8.0
[6] Surface permeability	1	3.0
[7] Sum of items 2 through 6	0.8	25.0
[8] Normalized score ([7] x 100/48)	0.8	52.08
[9] Flooding potential	1	0
[10] Adjusted surface water pathways score (sum 8,9 or 100)	0.8	52.08
[11] Waste containment effectiveness factor for surface water	1	0.1
[12] Final score for surface water pathways ([10] x [11])	0.8	5.21

Press any key to continue

Press any key to continue into the Groundwater Pathways evaluation. The first question of this section is about observed releases in groundwater. Enter 1 as an answer.

```
                              SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
[13] Observed releases in groundwater
- GROUNDWATER PATHWAYS ------------------------------------------------------

Have contaminants been detected in groundwater?

1.      yes
          Must be based on: (I) at least one analytical determination
          in which contaminants were present in groundwater at a level
          that represents a significant increase above background,
          AND, (II) an indication that the contaminants migrated from the
          rated site via groundwater transport routes

2.      no
(If contaminants are equally likely to have come from several sources
select "no" and note the reason for this in the Comments.)

[ 1 2 ]> 1

        <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

Proceed with answering the remaining questions of Groundwater Pathways.

```
                         Groundwater Pathways
                          SITE: Area Spill #2
D S R P M   factor                                           SCORE   RESULT

[13] Observed releases in groundwater                        100.0   100.0
[14] Depth to the groundwater table
[15] Permeability of the unsaturated zone
[16] Infiltration potential
[17] Sum of items 14 through 16
[18] Normalized score ([17] x 100/57)
[19] "Short-circuit" potential to the water table
[20] Adjusted groundwater pathways score (sum 8,9 or 100)            100.0
[21] Waste containment effectiveness factor for groundwater  0.1     0.1
[22] Final score for groundwater pathways ([20] x [21])              10.0

     <Any key> Continue   <F2> Confidence levels   <Esc> Exit
```

After ADPM has calculated the final score for Groundwater Pathways press any key to continue into the Air/Soil Pathways. After ADPM has calculated the final score for Air/Soil Pathways it will attempt to calculate the Contaminant hazard of the DPM model. This is done in the Hazard Worksheet which is displayed on the screen. You are asked to give a contaminant name.

```
                    Chemical database match

CONTAMINANT HAZARD -- SURFACE WATER
                 HAZARD WORKSHEET -- No Observed Releases

   1  Contaminant Name

   3  Health Effects Benchmark (µgr/day)............
   4  Aquatic Effects Benchmark (µgr/Liter).........
   5  Terrestrial Effects Benchmark (µgr/Liter).....
   6  Bioaccumulation Factor (Liter/kg).............

   7  Health Hazard Index...........................
   8  Aquatic Hazard Index..........................
   9  Terrestrial Hazard Index......................

   10 Maximum Health Hazard Index....................
   11 Maximum Aquatic Hazard Index...................
   12 Maximum Terrestrial Hazard Index...............

         <Enter> Continue      <Esc> Return to main menu
```

If the name of the chemical is found in the Chemicals database ADPM will retrieve the health and ecological hazard benchmarks from the database and display them in the worksheet. ADPM searches for a match in its database as you are typing the chemical's name and displays the first three matches on top of the screen.

If the name of the chemical you want to use is first on the screen you do not need to finish off typing. Press <Enter> and ADPM fills out the remaining rows of the hazard worksheet.

```
                         Chemical database match
Chloroform   Dichlorofluoromethane   Trichlorofluoromethane
                                                              ...More
- CONTAMINANT HAZARD -- SURFACE WATER
                 HAZARD WORKSHEET -- No Observed Releases

  1  Contaminant Name chlorof

  3  Health Effects Benchmark (µgr/day)............
  4  Aquatic Effects Benchmark (µgr/Liter).........
  5  Terrestrial Effects Benchmark (µgr/Liter).....
  6  Bioaccumulation Factor (Liter/kg).............

  7  Health Hazard Index...........................
  8  Aquatic Hazard Index..........................
  9  Terrestrial Hazard Index......................

  10 Maximum Health Hazard Index...................
  11 Maximum Aquatic Hazard Index..................
  12 Maximum Terrestrial Hazard Index..............

           <Enter> Continue     <Esc> Return to main menu
```

Press <Enter> to continue. You are prompted again for a contaminant name. If the name of the chemical is not found in the database, in addition you will be prompted to give the chemicals health and ecological hazard indices.

```
                         Chemical database match

CONTAMINANT HAZARD -- SURFACE WATER
                 HAZARD WORKSHEET -- No Observed Releases

  1  Contaminant Name xyz

  3  Health Effects Benchmark (µgr/day)............ 1
  4  Aquatic Effects Benchmark (µgr/Liter)......... 2
  5  Terrestrial Effects Benchmark (µgr/Liter)..... 3
  6  Bioaccumulation Factor (Liter/kg)............. 4

  7  Health Hazard Index...........................
  8  Aquatic Hazard Index..........................
  9  Terrestrial Hazard Index......................

  10 Maximum Health Hazard Index...................      1.0
  11 Maximum Aquatic Hazard Index..................      1.0
  12 Maximum Terrestrial Hazard Index..............      1.0

           Enter a positive number or  <Enter> to Continue
```

If there are not any other chemicals for the surface water evaluation press <Enter> and ADPM will continue with the next question. Now ADPM attempts to calculate the contaminant hazard for Groundwater and you are prompted for a chemical name once again.

```
                      Chemical database match
Acenaphthene    Acetone    Arsenic
                                                          ...More
CONTAMINANT HAZARD -- GROUNDWATER
                 HAZARD WORKSHEET -- Observed Releases

 1  Contaminant Name c

 2  Concentration (µgr/Liter).....................|
 3  Health Effects Benchmark (µgr/day)............|
 4  Aquatic Effects Benchmark (µgr/Liter).........|
 5  Terrestrial Effects Benchmark (µgr/Liter).....|
 6  Bioaccumulation Factor (Liter/kg).............|

 7  Drinking Water Intake (µgr/day) [2] x 2 ......|
 8  Food Intake (mgr/day) [2] x [6] x 0.0065 .....|
 9  Total Intake (mgr/day) [7] + [8] .............|

10  Health Hazard Quotient [9]/[3]                |SUM
11  Aquatic Hazard Quotient [2]/[4]               |SUM
12  Terrestrial Hazard Quotient [2]/[5]           |SUM

          <Enter> Continue     <Esc> Return to main menu
```

In addition, since previously you answered yes to the question whether contaminants have been released in groundwater, now you will be prompted to give the concentration of each contaminant. When you answer ADPM finds the chemical name in its database, retrieves the toxicity benchmarks of the chemical, and uses them to calculate the Hazard Worksheet.

```
                      Chemical database match
Chloroform    Dichlorofluoromethane    Trichlorofluoromethane
                                                          ...More
CONTAMINANT HAZARD -- GROUNDWATER
                 HAZARD WORKSHEET -- Observed Releases

 1  Contaminant Name chlorof

 2  Concentration (µgr/Liter).....................|1
 3  Health Effects Benchmark (µgr/day)............|
 4  Aquatic Effects Benchmark (µgr/Liter).........|
 5  Terrestrial Effects Benchmark (µgr/Liter).....|
 6  Bioaccumulation Factor (Liter/kg).............|

 7  Drinking Water Intake (µgr/day) [2] x 2 ......|
 8  Food Intake (mgr/day) [2] x [6] x 0.0065 .....|
 9  Total Intake (mgr/day) [7] + [8] .............|

10  Health Hazard Quotient [9]/[3]                |SUM
11  Aquatic Hazard Quotient [2]/[4]               |SUM
12  Terrestrial Hazard Quotient [2]/[5]           |SUM

          Enter a positive number or  <Enter> to Continue
```

You may continue giving chemical names and their concentration. If a chemical is not in the database you will be prompted to provide the various toxicity benchmarks.

```
                         Chemical database match

- CONTAMINANT HAZARD -- GROUNDWATER ----------------------------------------
                    HAZARD WORKSHEET -- Observed Releases
    1  Contaminant Name xyz

    2  Concentration (µgr/Liter).....................|1
    3  Health Effects Benchmark (µgr/day)............|2
    4  Aquatic Effects Benchmark (µgr/Liter).........|3
    5  Terrestrial Effects Benchmark (µgr/Liter).....|4
    6  Bioaccumulation Factor (Liter/kg).............|5

    7  Drinking Water Intake (µgr/day) [2] x 2 ......|
    8  Food Intake (mgr/day) [2] x [6] x 0.0065 .....|
    9  Total Intake (mgr/day) [7] + [8] .............|

    10 Health Hazard Quotient [9]/[3]                |SUM 0.49
    11 Aquatic Hazard Quotient [2]/[4]               |SUM 0.0000346
    12 Terrestrial Hazard Quotient [2]/[5]           |SUM

              Enter a positive number or  <Enter> to Continue

                         Chemical database match

  CONTAMINANT HAZARD -- GROUNDWATER ----------------------------------------
                    HAZARD WORKSHEET -- Observed Releases
    1  Contaminant Name xyz

    2  Concentration (µgr/Liter).....................|1.0
    3  Health Effects Benchmark (µgr/day)............|2.0
    4  Aquatic Effects Benchmark (µgr/Liter).........|3.0
    5  Terrestrial Effects Benchmark (µgr/Liter).....|4.0
    6  Bioaccumulation Factor (Liter/kg).............|5.0

    7  Drinking Water Intake (µgr/day) [2] x 2 ......|2.0
    8  Food Intake (mgr/day) [2] x [6] x 0.0065 .....|0.03
    9  Total Intake (mgr/day) [7] + [8] .............|2.03

    10 Health Hazard Quotient [9]/[3]      1.02      |SUM 1.59
    11 Aquatic Hazard Quotient [2]/[4]     0.33      |SUM 0.3300346
    12 Terrestrial Hazard Quotient [2]/[5]0.25       |SUM 0.25

              <Any key> Continue    <Esc> Exit to main menu

                         Chemical database match
```

In the next stage ADPM will evaluate the hazard scores for Air/Soil. If you have answered yes to either [23] or [24] the concentration will be calculated using the various model equations. Once you have entered the chemical name ADPM will take you through a series of questions pertaining to that chemical and the site. These values are then used to calculate the concentration, which is then entered into the worksheet.

```
                         Chemical database match
toluene    2-Amino-4,6-dinitro toluene    2,4-Dinitrotoluene
                                                                 ...More
 Q U I T
                  HAZARD WORKSHEET -- Observed Releases

   1  Contaminant Name toluene

   2  VOC air Concentuation (g/cu m)................  0.00013334
   3  Soil Concentration (mg/kg)....................  2.0
   4  Fug dust air concentration (g/cu m)...........  0.00000062
   5  Health Effects Benchmark (µgr/day)............  24.0
   6  Terrestrial Effects benchmark(µgr/L)..........

   7  Inhalation Intake (µgr/day)...................  2666.79
   8  Soil Ingestion intake(µgr/day) ...............  0.33
   9  Total Intake (µgr/day) [7] + [8] .............  2667.12

  10  Health Hazard Quotient [9]/[5]      111.13      SUM 111.13
  11  Terrestrial Hazard Quotient [2]/[5]             SUM

           <Any key> Continue <Esc> Exit to main menu
```

When you are finished with the chemicals press <u><Enter></u>, and ADPM will move into the calculation of **Surface Water Receptors**. The consultation follows in a similar fashion with questions asked in the Dialog Window and the current scores displayed at the top of the screen. For some of the questions in this category, such as population within 1000 feet, the answers could be identical with those in the subsequent DPM section (Groundwater Receptors).

```
                       SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[45] Population within 1000 feet of the site -- surface water
HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

What is the size of the population within 1000 feet of the site?

[ positive number ]▸ 10

        <F1> Explain    <F2> Confidence scale    <Esc> Main menu
```

For this reason, when you answer this question, a pop-up window appears at the bottom of the screen and asks if additional values could be assumed. In this case, it asks whether population within 1000 feet could be assumed to be the same for the groundwater pathway. Press <u>y</u> to confirm this. Later on, in the evaluation of the groundwater pathway, you will not be asked about population within 1000 feet.

```
                       SITE: Area Spill #2
D S R P M   factor                                          SCORE   RESULT
[45] Population within 1000 feet of the site -- surface water
HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

What is the size of the population within 1000 feet of the site?

[ positive number ]▸ 10

  Assume additional values
  It may be reasonable to assume as known also:
  [58] Population within 1000 feet of the site -- groundwater = 10.0
  Could also be assumed? [y]▸

            <y> Accept value   <any key> Continue
```

The next questions take you through the Surface Water Receptors and the Groundwater Receptors. Three of the factors here may require additional consideration. These factors are [54], [55], and [62], which calculate the groundwater travel time. You will be prompted for the parameters needed, such as the distance from the current waste location to (another) water-supply well.

```
                              SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
[54] Estimated groundwater travel time to supply wells
- HUMAN HEALTH RECEPTORS -- GROUNDWATER PATHWAY

What is the distance from the current waste location to the nearest
downgradient water-supply well(s)?

[ positive number ]• 1000         feet

              <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

After providing also the data for aquifer permeability, aquifer porosity, and hydraulic gradient, the groundwater travel time is calculated and the score of factor [54] is shown on the top display window.

```
                              SITE: Area Spill #2
D S R P M   factor                                              SCORE   RESULT
[54] Estimated groundwater travel time to supply wells
- HUMAN HEALTH RECEPTORS -- GROUNDWATER PATHWAY

What is the distance from the current waste location to the nearest
downgradient water-supply well(s)?

[ positive number ]• 1000         units(feet)

What is the effective porosity of the affected aquifer? [HELP: F1]

[ X > 0 , X < 1  ]• 0.1

What is the hydraulic conductivity of the affected aquifer? [HELP: F1]

[ positive number ]• 1            feet/day

What is the hydraulic gradient in the affected aquifer?

[ X > 0 , X < 0.5  ]• 0.001

              <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

According to the decision-logic of the DPM model, you may need to calculate each of these factors more than once in order to obtain the highest score for different site conditions. In ADPM, this can be done by using the Change option of the Main Menu, providing new values and recalculating the score.

```
 D P M    System  | Change | Explain                          Next
 Q U I T ---------  General Site Information
                    --------------------------------------
                    Surface Water Pathways
                    Air Pathways
                    Groundwater Pathways
                    --------------------------------------
                    Surface Water Hazard
                    Groundwater Hazard
                    Air Hazard
                    --------------------------------------
                    Surface Water Human Health Receptors
                    Surface Water Ecological Receptors
                    --------------------------------------
                    Air Human Health Receptors
                    Air Ecological Receptors
                    --------------------------------------
                    Groundwater Human Health Receptors
                    Groundwater Ecological Receptors

        <Arrows> Move      <Enter> Select      <Esc> Cancel
```

You may then proceed with the remaining questions.

Human Health Receptors -- Groundwater Pathway

SITE: South FTA

D P M	factor	SCORE	RESULT
[77]	Estimated groundwater travel time to supply wells	0	0
[78]	Estimated groundwater travel time to surface water	0	0
[79]	Groundwater use of the uppermost aquifer	3.0	12.0
[80]	Population at risk from groundwater contamination	24.0	24.0
[81]	Population within 1000 feet of the site -- groundwater	2.0	2.0
[82]	Distance to nearest installation boundary -- groundwater	3.0	3.0
[83]	Sum of items 77 through 82		41.0
[84]	Final score for human health receptors -- gw ([83] x 100/96)		42.71

<Any key> Continue <F2> Confidence levels <Esc> Exit

Now you may wish to get a printout of the results, or send the output to an ASCII file. Press s to select the System option from the Main Menu. Choose Print data for a printout.

```
 D P M     System     Change     Explain                          Next
- P R I N T   D A T A
 Print data? [y]»

                 <Any key> Print     <y> Write to a file     <Esc> Cancel
```

If you choose Write to a file you will be prompted to give a filename to write the results.

```
 D P M     System     Change     Explain                          Next
 WRITE DATA TO A FILE
 Print data? [y]» y
 File name » example

                         <Enter> Return to main menu
```

After the last question you will see the final screen that displays a summary of all the DPM scores. Press any key to continue and return to the Main Menu.

```
                              DPM -- Scoring Summary
                                 SITE: North FTA
                                                              SCORE    RESULT
D P M   factor

[99] Surface water/human health score                                   1.36
[100] Surface water/ecological score                                    3.4
[101] Groundwater/human health score                                    8.7
[102] Groundwater/ecological score                                      5.68
[103] air/human health score                                            53.7
[104] air/ecological score                                              26.85
[105] sqrt(5x[99]^2 + [100]^2 + 5x[101]^2 + [102]^2 + 5x[103]^2 + [104]^2124.79
[106] Overall site score ([105] / 4.24)                                 29.41




           <Any key> Continue    <F2> Confidence levels    <Esc> Exit
```

```
OVERALL SITE SCORE
                                 S U M M A R Y

A. Installation :  Luke AFB
B. Site name    :  North FTA
C. Location     :  Luke AFB
D. Reviewer     :  Chid Subramanian
E. Date         :  Wednesday, May 31, 1989

 [12] Final score for surface water pathways ([10] x [11])              18.33
 [22] Final score for groundwater pathways ([20] x [21])                59.65
 [35] Final score for air/soil pathway ([34] x [33])                    80.56
 [43] Normalized health hazard index -- sw ([42] x 100/9)               33.33
 [45] Normalized ecological hazard index -- sw ([44] x 100/6)           33.33
 [53] Normalized health hazard index -- gw ([52] x 100/9)               33.33
 [55] Normalized ecological hazard index -- gw ([54] x 100/6)           33.33
 [58] Normalized human health hazard score --air ([57] x 100/6)         100.0
 [61] Normalized ecological hazard score -- air ([50] x 100/6)          50.0
 [72] Final score for human health receptors -- sw ([71] x 100/27)      22.22
 [76] Final score for ecological receptors -- sw ([75] x 100/18)        55.56
 [84] Final score for human health receptors -- gw ([83] x 100/96)      43.75
 [89] Final score for ecological receptors -- gw ([88] x 100/21)        28.57
 [94] Final score for ecological receptors -- gw ([93] x 100/39)        66.67
 [98] Final score for ecological receptors on air pathways ([97] x 10066.67
 [106] Overall site score ([105] / 4.24)                                29.41

          <Arrows> Move        <Enter> Select        <Esc> Cancel
```

If you want to examine a new site press n, for Next, and you will be prompted for a file name to save the data. This will clear the database for a new session.

```
   D P M     System     Change     Explain                           Next
- N E X T ----------------------------------------------------------------
                   Database will be erased... Save your data
Filename for saving data [*.*] >



                         <Enter> Return to main menu
```

At this point you may wish to end the consultation. Press s followed by a q to select Quit from the System menu and you will see the following screen. Press <y> to end ADPM and you will return to MS-DOS.

```
   D P M     System     Change     Explain                           Next
  Q U I T ----------------------------------------------------------------


                        Quit ADPM? [y]



           <y> Quit ADPM    <Any key> Return to main menu
```

Chapter 3

ADPM MENU OPTIONS

This section briefly describes each of the options available in the ADPM menu. More detailed information was provided in the previous section, which discussed how to use the various elements of ADPM, such as the DPM, Change, Input, and Output options.

3.1 Using DPM for Site Evaluation

Selecting DPM from the Main Menu activates the DPM model for site evaluation. Pressing <Enter><Enter> from the Main Menu starts the evaluation and the DPM scores are calculated. If all the data needed for scoring the site are known, then the calculation proceeds to the end, and the final rating of the site is displayed.

When a factor needed for the DPM rating is unknown, the system will ask you the question associated with the factor. You may press the <F1> function key to obtain a further explanation on the question.

If you do not feel confident of an answer press the <F2> key. You are prompted to enter a confidence level. This confidence level corresponds to a "confidence scale" of 0 to 1. A confidence level of 1 has the meaning of absolute certainty, whereas a confidence level of 0 has the meaning of absolutely not certain. Confidence levels between 1 and 0 indicate some degree of certainty with 0.5 meaning that there is more certainty of truth than there is of not truth. The use of the confidence scale does not affect the site rating but is used as an indication of the relative confidence of the rater to the ADPM questions.

ADPM will only accept answers that are legal responses to a question. For example, if the answer requires a number, text is not accepted and you are prompted to answer again. In a few questions, such as for "Net precipitation" there might be alternative ways for evaluating the answer. In that case, ADPM allows you to press the <Enter> key and move on to the next available question. Pressing the <Enter> key is equivalent to answering unknown to the question.

You may exit the questioning mode by pressing <Esc>. This will take you back to the Main Menu where you can choose other options. When you want to continue the consultation, press

<Enter><Enter> and you will be back to the point where you left off. This means that if you have already given the data by some other option (e.g. through consulting a file, or through the Change option), ADPM will not re-ask you the same question. However, if the answer remains unknown, you will be asked the same question again.

```
                              SITE: Area Spill #2
D S R P M   factor                                               SCORE   RESULT
[6] Surface permeability
┌ SURFACE WATER PATHWAYS ──────────────────────────────────────────────────────
|
|What is the surface soil permeability based on field/laboratory measurements?
|(The presence of any engineered containment structures that modify
|surface permeability should not be considered in evaluating this factor.)
|
|[ positive number ]•                cm/sec
|
└──────────────────────────────────────────────────────────────────────────────
  <Enter> Estimate   <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

```
                              SITE: Area Spill #2
D S R P M   factor                                               SCORE   RESULT
[6] Surface permeability
┌ SURFACE WATER PATHWAYS ──────────────────────────────────────────────────────
|
|What is the surface soil permeability based on field/laboratory measurements?
|(The presence of any engineered containment structures that modify
|surface permeability should not be considered in evaluating this factor.)
|
|[ positive number ]•                cm/sec
|
|What is the clay content of the surface soils?
|
|1.      Less than 15% clay.
|2.      Between 15% to 30% clay.
|3.      Between 30% to 50% clay.
|4.      More than 50% clay.
|
|[ 1 2 3 4 ]•
|
└──────────────────────────────────────────────────────────────────────────────
         <F1> Explain   <F2> Confidence scale   <Esc> Main menu
```

3.2 The Change Option

The Change option in the Main Menu is used to selectively change existing data. First select a DPM scoring category from the menu. ADPM then displays the known DPM factors and their values. Use the <Up> and <Down> arrow keys to move from item to item. Press <Enter> to make a selection. ADPM will ask the question associated with the factor selected, and based on your answer will recalculate the score of the DPM category.

```
 D P M    System  | Change | Explain                                  Next
 Q U I T          | General Site Information              |
                  | Surface Water Pathways                |
                  | Air Pathways                          |
                  | Groundwater Pathways                  |
                  | Surface Water Hazard                  |
                  | Groundwater Hazard                    |
                  | Air Hazard                            |
                  | Surface Water Human Health Receptors  |
                  | Surface Water Ecological Receptors    |
                  | Air Human Health Receptors            |
                  | Air Ecological Receptors              |
                  | Groundwater Human Health Receptors    |
                  | Groundwater Ecological Receptors      |

          <Arrows> Move       <Enter> Select       <Esc> Cancel
```

```
                 Human Health Receptors -- Groundwater Pathway
                              SITE: South FTA
D P M   factor                                                    SCORE   RESULT

[77] Estimated groundwater travel time to supply wells              0       0
[78] Estimated groundwater travel time to surface water             0       0
[79] Groundwater use of the uppermost aquifer                       3.0     12.0
[80] Population at risk from groundwater contamination              24.0    24.0
[81] Population within 1000 feet of the site -- groundwater         2.0     2.0
[82] Distance to nearest installation boundary -- groundwater       3.0     3.0
[83] Sum of items 77 through 82                                             41.0
[84] Final score for human health receptors -- gw ([83] x 100/96)           42.71

         <Any key> Continue   <F2> Confidence levels   <Esc> Exit
```

3.3 The Explain Option

The Explain option on the Main Menu is used to selectively display the explanations associated with each one of the DPM rating factors. Normally, these explanations are available by pressing the <F1> key when you are being asked a question. This menu allows you to select any DPM factor and quickly examine the explanation. This is done by first selecting a DPM category from the menu. Then use the <Up> and <Down> arrow keys to select a factor and press <Enter> to display the explanation.

```
 D P M    System | Change | Explain                          Next
 Q U I T         | General Site Information                 |
                 | Surface Water Pathways                   |
                 | Air Pathways                             |
                 | Groundwater Pathways                     |
                 | Surface Water Hazard                     |
                 | Groundwater Hazard                       |
                 | Air Hazard                               |
                 | Surface Water Human Health Receptors     |
                 | Surface Water Ecological Receptors       |
                 | Air Human Health Receptors               |
                 | Air Ecological Receptors                 |
                 | Groundwater Human Health Receptors       |
                 | Groundwater Ecological Receptors         |

          <Arrows> Move      <Enter> Select      <Esc> Cancel
```

```
                         Surface Water Pathways

 [11a] Type of facility -- surface water
 [11b] Landfill
 [11c] Surface impoundment
 [11d] Spill
 [11e] Former fire protection training area
 [11f] Aboveground tanks
 [11g] Site within enclosed structures
 [1] Observed releases in surface water
 [2] Distance to nearest surface water (feet)
 [3a] Net precipitation (inches)
 [3b] Average annual precipitation (inches)
 [3c] Average annual evaporation (inches)
 [4a] Surface erosion potential
 [4b] Enclosed depression below grade
 [4c] Surface slope of the site
 [4d] Vegetative cover of site surface
 [5] Rainfall intensity (inches)
 [6a] Surface permeability (cm/sec)
 [6b] Clay content of surface soils
 [9] Flooding potential

    <Up- Down- arrows> Move     <Enter> Select     <Esc> Main Menu
```

3.4 The Retrieve File Option

The **Retrieve File** option on the ADPM System Menu is used to retrieve files with previously stored data. Once these data are read in you may immediately proceed with scoring the site. Press sr from the Main Menu (for System/Retrieve) and you will see:

```
 D P M    System    Change    Explain                                Next
-R E T R I E V E   D A T A
Filename for data input  [*.*] *


                 <Enter> Return to main menu
```

Type in a filename where you have previously stored data. Such a file can either be created after saving one ADPM session or by using a text editor to prepare an ASCII file of the format needed for ADPM. The last chapter explains how to prepare such files for input.

```
 D P M    System    Change    Explain                                Next
-R E T R I E V E   D A T A
Filename for data input  [*.*] * adpm.dat

RETRIEVE DATA:
groundwater_release , yes
land_use , high
location , $Myrtle Beach, SC$
rainfall_intensity , 4
rainfall_intensity , [$From map in user's manual rainfall = 3.5 to 4 inches$]
chlorobenzene , wks(groundwater,2,10.0)
chlorobenzene , wks(groundwater,3,2600.0)
chlorobenzene , wks(groundwater,4,15900)
chlorobenzene , wks(groundwater,6,450)
chlorobenzene , wks(groundwater,7,20.0)
chlorobenzene , wks(groundwater,8,29.25)
chlorobenzene , wks(groundwater,9,49.25)

                         Reading...
```

3.5 The Print Data Option

The **Print Data** Option on the System Menu is used to send the ADPM results to an ASCII file. Press <u>sp</u> from the main menu (for System/Print) and you will see:

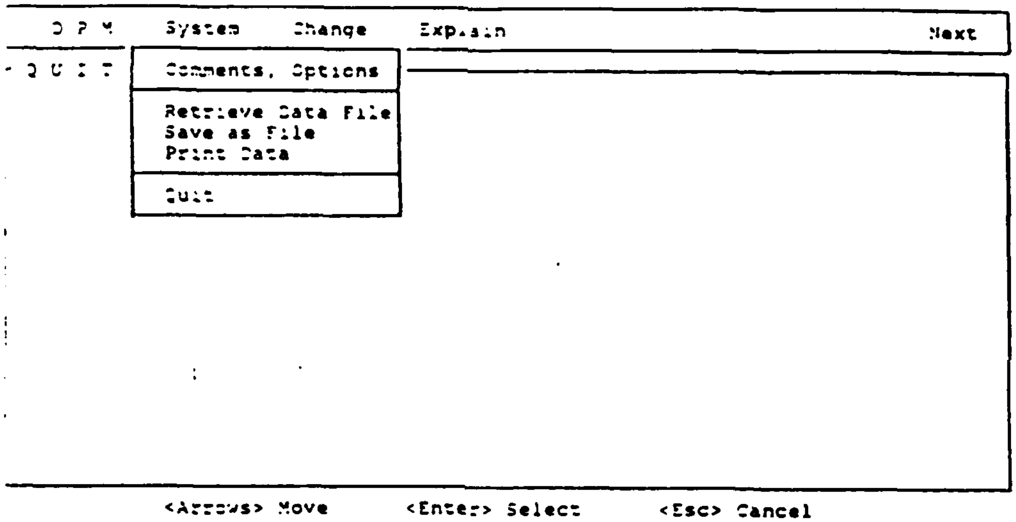
```
  D P M     System     Change     Explain                         Next
- P R I N T   D A T A ----------------------------------------------
 Print data? [y]:
 Printing...




                           Printing...
```

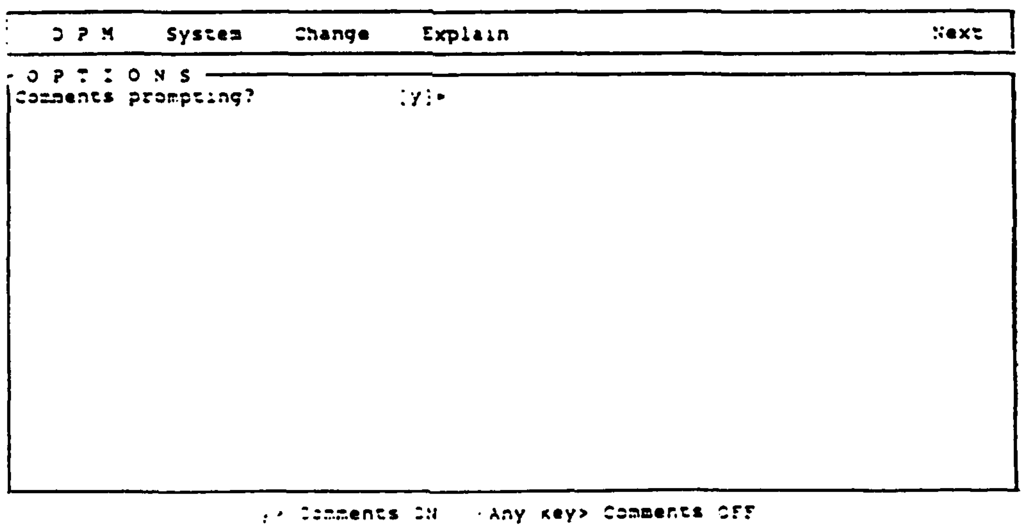
ADPM prompts you for the name of a file where you went to send the results. A three letter extension is needed for this filename.

```
  D P M     System     Change     Explain                         Next
- WRITE DATA TO A FILE ---------------------------------------------
 Print data? [y]: y
 File name : example




                     <Enter> Return to main menu
```

3.6 Comments and Other Options

The Comments option on the System Menu is used to switch the comments prompt on or off when you provide data to the DPM model. Press s followed by a c from the Main Menu (for System/Comments) and you will see the following screen. This question is a toggle that switches the Comments option on and off. Thus, if you press y you will (re)activate the comments. If you press any other key you will not be prompted for comments right after giving data to a DPM rating factor.





Likewise, the user may toggle on/off other ADPM options:

Display — After evaluating a DPM category, e.g. Surface Water Pathways, ADPM displays intermediate results.

Assume — ADPM attempts to derive additional values based on expert assumptions every time the user answers a question.

Warn — ADPM checks the user's answers for some DPM factors whether they are whithin a certain reasonable range, and if they are not it displays a warning.

```
  D P M     System     Change     Explain                              Next

 O P T I O N S
Comments prompting?                {y}•        option OFF
Assumed values prompting?          {y}•        option OFF
Display intermediate results?      {y}•        option OFF
Display warning messages?          {y}•        option OFF

              <Arrows> Move     <Enter> Select     <Esc> Cancel
```

3.7 The Save as a File Option

This option is used to save the data entered by the user at any time during an ADPM session. Press s followed by an s from the Main Menu (for System/Save) and you will see:

```
 D P M     System    Change    Explain                               Next
 Q U I T  | Contents, Options    |
          |----------------------|
          | Retrieve Data File   |
          | Save as File         |
          | Print Data           |
          |----------------------|
          | Quit                 |

            <Arrows> Move      <Enter> Select      <Esc> Cancel
```

You are prompted to give a file name to save the current database. Once you have stored the data in such a file, later on, you can retrieve it at any time you will use ADPM again. The name of the file has to be an acceptable MS-DOS file name.

```
 D P M     System    Change    Explain                               Next
 S A V E   A S   F I L E
Filename for saving data [*.*] ►

                      <Enter> Return to main menu
```

3.8 The Next Option

The Next option is used to clear the ADPM database and prepare the system to evaluate a new site. Press n from the Main Menu and you will see:

```
  D P M    System    Change    Explain                          Next
- N E X T ----------------------------------------------------------
               Database will be erased... Save your data
 Filename for saving data [*.*] ▸




                     <Enter> Return to main menu
```

Like the save option, you are prompted to give a file name to save the current database. Once you have stored the data in such a file, later on, you can retrieve it at any time you will use ADPM again.

```
  D P M    System    Change    Explain                          Next
- N E X T ----------------------------------------------------------
               Database will be erased... Save your data
 Filename for saving data [*.*] ▸
 Clearing database...  READY FOR NEXT SITE.




        <Arrows> Move       <Enter> Select       <Esc> Cancel
```

Chapter 4

THE ADPM DATA FILES

ADPM contains the database of chemical toxicity benchmarks that was included in the DPM site rating manual [1]. ADPM also contains on-line documentation and explanation of the various DPM factors as defined in that manual. This chapter explains how to modify and/or add to these databases. The last section describes the various data files used for ADPM input and output, and explains how to modify or create such input data files. Since all of these files are standard ASCII files, they can be modified using any text editor. By making a copy of these files and using their existing format as a template, you can modify and/or add to these databases by simply using your text editor.

Knowing how to modify or create such files is not necessary in order to fully utilize ADPM. Therefore, this chapter is intended for advanced users of ADPM. Also, in subsequent versions of ADPM, the procedures described in this chapter will be simplified or eliminated. The following sections are thus included for the purposes of completeness of documentation.

4.1 Chemicals Database

The ADPM Chemicals Database consists of a single ASCII file; this file is called:

<u>CHEMICAL.ARI</u>

The entries in this database look as follows:

```
c('Acenaphthene',$83-32-9$,0.40E+02,$EPA$,1700.00,$$,390.00,3,2).
c('Acetone',$67-64-1$,0.40E+02,$RASH$,10000.00,$$,0.16,2,1).
c('Aldrin',$309-00-2$,0.90E-06,$EPA$,3.00,$$,11000.00,9,4).
c('Aluminum',$7429-90-5$,3.00E+00,$RASH$,$$,5000,$$,$$,2).
c('Antimony',$7440-36-0$,0.29E+03,$EPA$,9000.00,$$,1.00,$$,2).
c('Arsenic',$7440-38-2$,0.04E+00,$EPA$,360.00,100,280.00,4,2).
c('Barium',$7440-39-3$,1.50E-01,$ACGIH$,14500.00,$$,4.00,2,1).
c('Baygon',$38777-13-8$,0.12E+00,$RASH$,13.00,5000,8.50,2,2).
c('Benzene',$71-43-2$,0.30E+02,$EPA$,5300.00,$$,32.00,2,2).
c('Benzidine',$92-87-5$,0.34E-02,$EPA$,2500.00,$$,41.00,5,2).
c('Beryllium',$7440-41-7$,0.17E+00,$EPA$,130.00,100,2.00,2,2).
```

Since this file can be edited using any text editor, it is possible to change entries in the database simply by editing the text in the file.

Additional entries can be made according to these format rules:

- Each entry starts with c(and ends with).

- The chemical name is the first field and must be enclosed in single quotes '

- The following fields are (in exact sequence): CAS No, Health effects benchmark, Source, Aquatic life benchmark, Irrigated crops benchmark, fish bioaccumulation, health hazard index, ecological hazard index.

- Non-numeric fields must be enclosed in dollar signs: $.

- Fields are separated by commas

The format looks as follows:

```
c(
        'Chemical Name',
        $CAS NO$,
        Health Effects Benchmark,
        $SOURCE OF BENCHMARKS$,
        Aquatic Effects Benchmark,
        Irrigated Crops Benchmark,
        Fish Bioaccumulation,
        Health Hazard Index,
        Ecological Hazard Index
).
```

If a field is not available just supply two dollar signs: $$.

Finally any line preceded by the percent sign, % is considered a comment and is ignored by ADPM.

4.2 Explanations Database

The Explanations Database also consists of a single ASCII file which can also be accessed and changed using any text editor. The file name is:

EXPLAIN.ARI

The Explanations Database consists of two parts:

Synonyms — These entries include most of the factors (or parameters) known to ADPM and their associated synonyms. These synonyms are used when displaying results or showing values to the user.

Explanations   This is the explanation text associated with each one of the DPM factors.

The synonym records follow the format:

```
s(
        'Factor Name',
        $SYNONYM$
).
```

The explanation records follow the format:

```
s(
        Factor_Name,
        $TEXT$,
        $TEXT$,
        ... ,
        $TEXT$
).
```

You can modify these records or add new records following the same rules as explained in the previous section regarding the chemical database.

4.3 ADPM Data Files

In addition to the database and explanation files ADPM may use other data files, either to import previously saved data, or to print its results.

4.4 ADPM output files

ADPM produces two kinds of output files. One kind is produced by the Print Data option of the Main Menu and the other kind is produced when a file is saved by the Save as File or Next option (or before exiting the system).

The files produced by the Output option are flat ASCII files which contain ADPM results. These files can either be sent directly to the printer or imported into one's word processor for creating reports. For example, one such file contained in your ADPM diskettes is the file RESULT.DAT.

The files produced when saving a session by ADPM are again ASCII files but follow certain format conventions. Since these files can be subsequently used for ADPM input their format is described next.

4.5 ADPM Input Files

An ADPM input file includes actual ADPM data. These are used by ADPM in calculating the various site scores. There are two kinds of ADPM input files: (1) ADPM saved data files, and (2) files created by the user.

An example of a file produced by saving your data when in ADPM is ADPM.DAT. An example of a user created file contained in your ADPM diskettes is INPUT.DAT.

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APPENDIX H

METHODOLOGY FOR CALCULATING HUMAN HEALTH AND ECOLOGICAL BENCHMARKS

DETERMINATION OF HUMAN HEALTH AND ECOLOGICAL BENCHMARKS

Human Health Effects Benchmarks

The Defense Priority Model (DPM) determines contaminant hazard scoring based on benchmarks for each compound identified from each site being scored. The benchmarks for each compound are determined by the concept of "acceptable daily intake" (ADI) as employed by the EPA for non-carcinogens. The ADI is based on a No Observed Effects Level (NOEL). Benchmark levels for carcinogens are based on the concentration level which predicts a risk of 1 death per 100,000 population. Both basically define a permissible concentration of a chemical for human exposure: "a concentration that, under typical exposure conditions, would not be expected to cause unacceptable adverse health effects." (Barnthouse et al., 1988)

Barnthouse et al. (1986,1988) give a detailed account describing the background and methodology for developing the benchmarks used for the DPM. For compounds in which well documented permissible concentrations have been developed by the EPA, these limits have been taken for benchmarks. EPA water quality criteria have been used as the primary source for benchmarks for the DPM. A secondary source for benchmarks has come from permissible concentrations developed for 58 chemicals derived from estimated relative carcinogenic potencies developed by EPA's Carcinogen Assessment Group (CAG).

The primary and secondary sources for benchmarks do not cover all the chemicals of interest for the DPM. For those compounds not covered by these sources, benchmarks have been developed based on relative potencies. Relative potency is used to compare the effect from one chemical to that of a standard chemical. The relative potency approach has been historically used for biomedical and risk-related decisions (Jones et al., 1988).

The relative potency methodology used for developing benchmarks for the DPM is the rapid screening of hazard method (RASH). The RASH methodology uses an assortment of relative potency values from a variety of biological tests and/or screening models. The number of values depends upon how extensively the chemical of interest has been studied. A detailed description of the RASH development and methodology is given elsewhere by Jones et al. (1985,1988). Also, Barnthouse et al.(1986, 1988) give a detailed description of the RASH method as applied to the DPM.

The first step in determining the benchmark for a chemical is calculating the potency of the compound relative to a standard compound. Benzo[a]pyrene (BaP) is selected as the primary standard for relative potency determinations for three reasons. The first reason is that BaP is one of the most widely tested compounds. Second, the CAG has developed estimates of permissible lifetime doses and concentrations of BaP in drinking water. Finally, other chemical scoring systems have used BaP as a standard.

There are twc basic methods for determining relative potency. The most commonly used method is to compare the dose required to induce the same effect. If dose x (in mg/kg) of a chemical of interest is required to produce an effect

Site activity is a measure of activities on the site which may cause fugitive dust emissions. Activities which may cause these emissions include vehicle traffic on paved or unpaved surfaces, material excavation and movement, open landfill operations, and excavation/remedial activities of sites. Assign a score of 0 for surface impoundments, otherwise assign a score as follows:

Site Activity	Score
No activity at site.	0
Activity at site limited to occasional vehicle traffic.	1
Moderate vehicle traffic and little or no excavation/material handling operations.	2
Heavy vehicle traffic daily or substantial activity including excavation and material handling.	3

Occasional vehicular traffic would include such things as intermittent security vehicle access and vehicular access for safety or environmental assessment personnel. Traffic would be less than 5 vehicle-trips per day. Moderate vehicular activity would include routine, though perhaps not daily, vehicular use of the site up to 15 vehicle-trips per day. Heavy vehicle traffic would involve more than 15 trips per day or fewer trips having extensive on-site vehicle movement. Generally, a vehicle-trip is assumed to be of short duration on-site perhaps with limited exposure to the entire site or simply as a means of access to adjacent property. If the vehicle-trips involve substantial on-site travel, use the next higher rating.

Waste Containment Effectiveness

The waste containment effectiveness factor adjusts the pathways score to account for the effectiveness of engineered barriers or clean-up actions in reducing the potential for contaminant transport along a particular pathway. The waste containment effectiveness factor is a multiplier with values ranging from 0.1 to 1.0. A value of 0.1 signifies optimum state-of-the-art containment and is assigned for the site if VOC and fugitive dust emissions are properly controlled. A value of 1.0 signifies little or no effective containment of VOC or fugitive dust emissions. Specific guidance on determining the waste containment efficiveness multiplier for surface water pathways should be obtained from Table 6. Note the basis for the selection of the multiplier in the "Comments" section of the score sheet.

Table H-1. Range of Possible RTECS Comparisons for an Extensively Tested Chemical*

Chemical	Biological test**	Type of estimate	Dose	Potency relative to BaP***
		Mutation Data		
UDMH	mmo-sat	--	42 umol/plate	
BaP	mmo-sat	--	333 ug/plate	0.13
UDMH	mma-sat	--	42 umol/plate	
BaP	mma-sat	--	5 ug/plate	2.0E-3
UDMH	mmo-esc	--	20 umol/L	
BaP	mmo-esc	--	1 ug/l	0.21
UDMH	dnd-esc	--	1 umol/L	
BaP	dnd-esc	--	500 ug/L	8.3E-3
UDMH	mmo-asn	--	250 nL/plate	
DMNA	mmo-asn	--	20 uL/plate	18
UDMH	dnd-mus-ipr	--	3500 umol/kg	
BaP	dnd-mus-ipr	--	500 mg/kg	2.4
UDMH	dni-mus-orl	--	200 mg/kg	
Benzene	dni-mus-orl	--	20 g/kg	0.5
UDMH	msc-mus:lym	--	5 mmol/(L*24 h)	
BaP	msc-mus:lym	--	10 mg/(L*4 h)	5.6E-3
UDMH	hma-mus/sat	--	125 mg/kg	
DMNA	hma-mus/sat	--	24,000 ug/kg	0.045
		Tumor Data		
UDMH	orl-rat	TDLO	150 mg/(kg*7wk) I	
BaP	orl-rat	TDLO	160 mg/(kg*6 d) C	1.1
UDMH	scu-rat	TDLO	21 mg/kg	
BaP	ipr-rat	TDLO	16 mg/kg	0.76
UDMH	ipr-mus	TDLO	144 mg/(kg*8 wk) I	
BaP	ipr-mus	TDLO	10 mg/kg	0.069
UDMH	orl-mus	TD	288 mg/(kg*8 wk) I	
DMNA	orl-mus	TDLO	80 mg/(kg*8 wk) C	0.064

Table H-1. Range of Possible RTECS Comparisons for an Extensively Tested Chemical*(continued)

Chemical	Biological test**	Type of estimate	Dose	Potency relative to BaP***
		Toxicity Data		
UDMH	ihl-rat	LC50	252 ppm/4 h	
DMNA	ihl-rat	LC50	78 ppm/4 h	0.088
UDMH	ipr-rat	LD50	102 mg/kg	
BaP	ipr-rat	LD50	50 mg/kg	0.49
UDMH	ihl-mus	LC50	172 ppm/4 h	
DMNA	ihl-rat	LC50	78 ppm/4 h	0.13
DMNA	ihl-mus	LC50	57 ppm/4 h	0.094
UDMH	ipr-mus	LD50	125 mg/kg	
BaP	scu-rat	LD50	50 mg/kg	0.40
UDMH	scu-mus	LD50	12 mg/kg	
BaP	scu-rat	LD50	50 mg/kg	4.2
UDMH	ihl-dog	LC50	3580 ppm/15 m3	
Benzene	ihl-mus	LC50	9980 ppm	0.018
UDMH	ipr-cat	LDLO	30 mg/kg	
BaP	ipr-mus	LDLO	500 mg/kg	17
UDMH	ihl-ham	LC50	392 ppm/4 h	
DMNA	ihl-rat	LC50	78 ppm/4 h	0.056
DMNA	ihl-mus	LC50	57 ppm/4 h	0.041

* Barnthouse et al., 1988.

** Symbols same as those used in RTECS. See Table H-2 for definition of symbols shown. See RTECS (Tatken and Lewis, 1983 and Lewis and Sweet, 1985) for a complete list of symbols and explanation of biological tests.

*** Doses coverted to mg/kg or mg/m3 for determining relative potency.

Table H-2. Symbols Used in Table H-1 to Describe Biological Test as Used in RTECS*

Test Abbreviation	RTECS Defination
mmo	Mutation in Microorganisms
mma	Microsomal Mutagenicity Assay
dnd	DNA Damage
dni	DNA Inhabitation
msc	Mutation in Mammalian Somatic Cells
hma	Host-Mediated Assay
sat	Salmonella typhimurium
esc	Escherichia coli
asn	Asperigillus nidulaus
ipr	Intraperitoneal
orl	Oral
scu	Subcutaneous
ihl	Inhalation
rat	Rat
mus	Mouse
dog	Dog, adult
cat	Cat, adult
ham	Hamster

* From Lewis and Sweet (1985).

An example for calculating relative potency for an exact match can be taken from the data in Table H-1. Under Mutation Data comparing UDMH with BaP for mmo-sat:

UDMH dose (x) = 42 umol/plate
UDMH molecular weight = 60 ug/umol
UDMH dose (x) = (42 umol/plate) x (60 ug/umol)
= 2520 ug/plate
BaP dose (y) = 333 ug/plate

Relative Potency = y/x = (333 ug/plate)/(2520 ug/plate)
= 0.13

An example for calculating relative potency for using a secondary standard also can be found in Table H-1. Under Mutation Data, comparing UDMH with benzene for dni-mus-orl:

UDMH dose (D_{test}) = 200 mg/kg
Benzene dose (D_{SS}) = 20 g/kg x 1000 mg/kg
= 20,000 mg/kg
(D_{BaP}/D_{SS})benzene = 0.0050

Relative Potency = (D_{BaP}/D_{SS}) x (D_{SS}/D_{test})
= (0.0050) x (20,000/200)
= 0.50

The median of all the relative potency values calculated is used as the overall relative potency of the chemical for use in the RASH methodology. The interquartile range of the relative potencies is taken as the measure of uncertainty. For the example given in Table H-1 for UDMH, the median potency is 0.13, with the interquartile range from 0.045 to 0.76. Barnthouse et al. (1988) give the median potency relative to BaP and interquartile range for 141 chemicals and 13 mixtures.

For chemicals with an insufficient amount of exact matches (either with the primary standard or secondary standards) a near match or reasonable match may be made. A near match may be made by matching species by similar lethality endpoints (such as LD_{50}s or LD_{LO}s) or from similar routes of intake compared within species. If near matches cannot be made, a reasonable match may be made by individuals highly experienced with toxicological literature and dose-response modeling. Barnthouse et al. (1988) give general guidelines for using the RASH method to determine relative potency in Table H-3 .

Once the potency of the chemical of interest is compared to benzo[a]pyrene, the value can be used to estimate permissible concentration of the chemical in water and the ADI. The CAG value of 0.03 ug/liter for polynuclear aromatic hydrocarbons has been used as the permissible concentration for the standard (BaP) by Jones et al. (1988), since "some PNAs are more toxic than B(a)P and others are less toxic." The ADI is computed by assuming an average consumption of 2 liters of water per day per person, so that the ADI for the standard BaP is:

(2 liters/day) x (0.03 ug/liter) = 0.06 ug/day

Table H-3. Selected Guidelines for Standardizing the RASH Analysis Method[1]

- Generally, attempt to match each test (or RTECS entry for the chemical being evaluated with one and only one test for the standard or reference chemical.
- If a listing in RTECS for the primary standard seems inconsistent with other entries for the standard, then look for a replacement value from the secondary standards.
- Always use the units mg/kg for comparisons.
- Never match tumors across species.
- Be cautious when matching tumors across strains within a species.
- Lethality can generally be matched across all strains and species unless novel pharmacological processes are involved.
- When many matches are possible, it may be desirable to use equal numbers of matches for some combination or all of the following: mutatation tests, reproductive tests, tumor assays, toxicity comparisons, and irritation tests. This is especially important if a chemical appears to be very potent in some categories and weak in others.
- Similar routes of administration may be matched as long as other experimental conditions remain fairly constant (e.g., subcutaneous, intraperitoneal, and intramuscular; or intratracheal and oral). When such matches are attempted, it is necessary to match treatment schedules as closely as possible.
- When considering tumor studies, treatment schedules lasting 4 to 12 weeks can be compared if the tumor count is taken many months after treatment ceases. When treatment intervals are long (e.g., more than 26 weeks), the treatment durations should match as closely as possible. For example, one test spanning 80 weeks may be matched with a test spanning 65 weeks but should probably not be matched with a test spanning 120 weeks. Generally, when test intervals are long, attempt matches only when $0.8 < t_1/t_2 < 1.2$.
- When evaluating treatments over time, make equivalent dosage comparisons (e.g., 2 ug/L for 2 hours is postulated to be approximately equivalent to 1 ug/L for 4 hours).

---

[1] Barnthouse et al., 1988.

Thus, the benchmark for BaP is 0.06 ug/day. The benchmark for the chemical of interest is computed by dividing the benchmark of the standard (BaP) by the toxicity of the chemical relative to the standard:

$$\text{Benchmark} = (BM_{std})/(RP_{test})$$

where

BM_{std} = Benchmark of the standard, in ug/day = 0.06 ug/day for BaP

RP_{test} = Potency of the chemical relative to the standard of BaP

For the example in Table H-1 shows a median relative potency of 0.13 for UDMH; the benchmark is calculated as:

$$\text{Benchmark} = (0.06 \text{ ug/day})/(0.13) = 0.44 \text{ ug/day}$$

Thus, the benchmark value for unsymmetrical dimethylhydrazine (UDMH) is 0.44 ug/day. This is the value found in Table B.1 of Appendix B.

Aquatic Life Benchmarks

When considering benchmarks for protection of aquatic life, two types of criteria are considered. The first is based on acute toxicity, the concentration not to be exceeded for a 1 hour average more than once in three years. The second criterion is based on chronic toxicity, the concentration not to be exceeded for any 4 day average more than once in 3 years. Barnthouse et al. (1988) give three bases for using the acute toxicity criteria, relating the differences in type of toxicological data used: median lethal (LC_{50}s) and median effective (EC_{50}s) concentrations for acute and maximum acceptable toxicant concentrations (MATCs) for chronic:

1. LC_{50} is the most common test of toxicity to aquatic life. Use of acute toxicity criteria for benchmarks would provide a large data set.

2. Chronic toxicity data are generally rare. Benchmarks based on chronic toxicity criteria would need to be derived from acute toxicity data, allowing for greater uncertainty.

3. MATC is an estimate of threshold based on life-cycle, partial-life-cycle, or early-life-cycle tests. The MATC is derived from hypothesis testing statistics corresponding to a variable level effect dependent upon a number of factors; thus, the MATC may occur at various levels of effect. LC_{50} and EC_{50} (used for acute criteria) correspond to a set level of effect, which allows for acute criteria ranking to better reflect actual relative toxicities of the chemicals.

For the chemicals of interest for the DPM, EPA water criteria were used when available for aquatic life benchmarks. The second source for aquatic life benchmarks, is EPA water criteria support documents, covering the lowest LC_{50} or

EC_{50} value, were used as benchmarks. A third source for aquatic benchmarks is from the EPA's ACQUIRE data base of aquatic toxicity data. ACQUIRE is available through the National Institutes of Health/U.S. Environmental Protection Agency Chemical Information System (CIS). Access to CIS is available through

Chemical Information Systems, Inc.
7215 York Road
Baltimore, MD 21212

If using the ACQUIRE for determining aquatic life benchmarks, use the lowest LC_{50} or EC_{50} value as the benchmark.

When using LC_{50} or EC_{50} values for determining aquatic life benchmarks, use values from tests at least 48 hours long. EC_{50} values should be based on immobilization, loss of equilibrium or incomplete shell development. Tests from any freshwater fish or invertebrate species of any life stage is acceptable. Benchmarks should not include values for water hardness, alkalinity or total dissolved solids. If a benchmark for a specific chemical is not available, use the benchmark for the category to which the chemical belongs (if available). When the benchmark for a category of chemicals is established, use the lowest LC_{50} or EC_{50} value for any member of the category.

Irrigated Crops Benchmarks

The 1972 Committee on Water Quality Criteria (CWQC) established water quality criteria for water intended for agricultural use for 18 elements with 3 elements added in the 1976 revision. The criteria were based on long term accumulation of the compounds in the soil and the thresholds for injury and reductions in growth and yield. The CWQC were applied as benchmarks to be used in the DPM for those compounds with criteria developed.

For organic pollutants, Barnthouse et al. (1988) state that since "...biodegradation is significant in surface soils, it is more reasonable to consider the direct, short-term effects of material dissolved in irrigation water..." so that the irrigated crops benchmarks are the "...lowest concentration of each chemical in a hydroponic nutrient solution or in irrigation water that results in a significant increase in injury symptoms or decreased growth yield or whole plants or plant part." The source used for these benchmarks is PHYTOTOX, a phytotoxicity data base developed for the EPA at the University of Oklahoma. PHYTOTOX is available from the same source as ACQUIRE.

Fish Bioaccumulation Benchmarks

The DPM uses fish bioaccumulation benchmarks as a factor to assess the potential of toxic chemicals to be accumulated by aquatic organisms which enter the food chains leading to humans. In general, for risk assessment purposes the concentration of a pollutant in fish is estimated by multiplying the concentration of the pollutant in water by a concentration factor (CF).

If the pathways of exposure for the fish include uptake from water and food, and the concentration of the chemical in the fish is considered to have reached steady state, the CF is called the bioaccumulation factor (BAF). If the pathway of exposure for the fish is only from uptake from water, and the concentration of the chemical in the fish is considered to have reached steady state, the CF is called the bioconcentration factor (BCF). The potential for an organic chemical to accumulate in an aquatic organism related to the chemical's lipophilicity. The lipophilicity of a chemical is measured by the octanol-water partition coefficient (K_{OW}) (Barnthouse et al. 1986 and 1988). A more detailed account describing BAFs and BCFs is as well as background information of the relationship of lipophilicity and K_{OW} is given by Barnthouse et al (1986, 1988).

If more than one value is available as an aquatic food chain accumulation factor, the following guidelines should be used. Whenever possible, a CF used in the DPM should be based on adequate field data if available. If adequate field data are not available, the second option is to base the CF on laboratory measurements to which approximate field values. If no measured values are available, the CF may be estimated based on octanol-water partition coefficients (K_{OW}) by the following regression equation (Barnthouse et al. 1988):

$$\log BCF = -0.56 + \log K_{OW}$$

The above regression equation has an r^2 value of 0.95 and n value of 16. Barnthouse gives several sources for obtaining K_{OW} information. Among those given are Trabalka and Garten (1982), Leo et al. (1971) and Hansch and Leo (1979). Barnthouse et al. (1986) also briefly describe the references and results for concentration factors for several metals in which they have developed.

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APPENDIX I

AIR/SOIL PATHWAY METHODOLOGY

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AIR/SOIL PATHWAYS

Observed Releases

If contaminants from the rated site have already been detected in air or soil, assign a score of 100 for this factor and proceed directly to the rating of waste containment effectiveness for the air/soil pathways. Otherwise, assign a score of zero and proceed to the scoring of pathway characteristics.

A finding that contaminants have been detected must be based on (1) at least one analytical determination in which contaminants were present in air or soil at a level that represents significant (in terms of demonstrating the contamination has occurred, no in terms of potential effects) increase above background, and (2) an indication that contaminants came from the rated site. If only one of several analyses indicated contamination and there is reason to suspect the validity of the analytical result, assign a score of zero and note the reason for this score in the "Comments" section of the score sheet.

Pathway Characteristics

Average soil temperature is an indicator for the volatilization rate of volatile compounds. It is defined as the annual average temperature of the site of interest (soil, landfill, or surface impoundment). If the average soil temperature is available, use that value. Otherwise, assume that the average soil temperature equals the mean ambient temperature. Assign a score as follows:

Temperature, $^{\circ}C$	Score
$< 0^{\circ}$	0
$\geq 0^{\circ}$	1
$\geq 15^{\circ}$	2
$\geq 25^{\circ}$	3

Net precipitation is an indicator of potential for reduction of the available pore space in the soil for diffusion of the volatile compounds. It is defined as average annual precipitation minus average lake evaporation. Where possible, data from local meteorological stations should be used for determining the annual net precipitation for scoring. When scoring for surface impoundments, enter a value of 0. Otherwise, assign a score as follows:

Net precipitation	Score
> +20 in. (>+508 mm)	0
+ 5 to +20 in. (+127 to +508 mm)	1
-10 to +5 in. (-254 to +127 mm)	2
< -10 in. (< -254 mm)	3

Wind velocity is a factor for determining the gas-phase mass transfer of the volatile from the site surface to the air. Scoring should be based on the annual average wind speed at the site. This can be obtained from the site report or estimated from Figure 1. Assign a score as follows:

Wind velocity, mi/hr	Score
> 0	0
≥ 5	1
≥ 10	2
≥ 15	3

Soil porosity is an indicator of the available air space for diffusion of volatile compounds through the matrix. For closed landfills, porosity of the cap should be used for scoring. For open landfills and contaminated soil, the porosity of the soil should be used for scoring. For surface impoundments, enter a score of 0. Assign a score as follows:

Soil Porosity*	Score
< 0.10	0
≥ 0.10	1
≥ 0.25	2
≥ 0.40	3

* Soil Porosity expressed as decimal fraction, not a percentage.

Days/year > 0.25 mm precipitation is a measure of the number of wet days per year which will naturally control fugitive dust emissions. The number of days with at least 0.25 mm (0.01 inch) precipitation should be obtained from local climatic data. If this data is unavailable, refer to Figure 5. Assign a score of 0 for surface impoundments, otherwise assign a score as follows:

Days/year > 0.25 mm precipitation	Score
>150	0
>100 and ≤150	1
>50 and ≤100	2
≤ 50	3

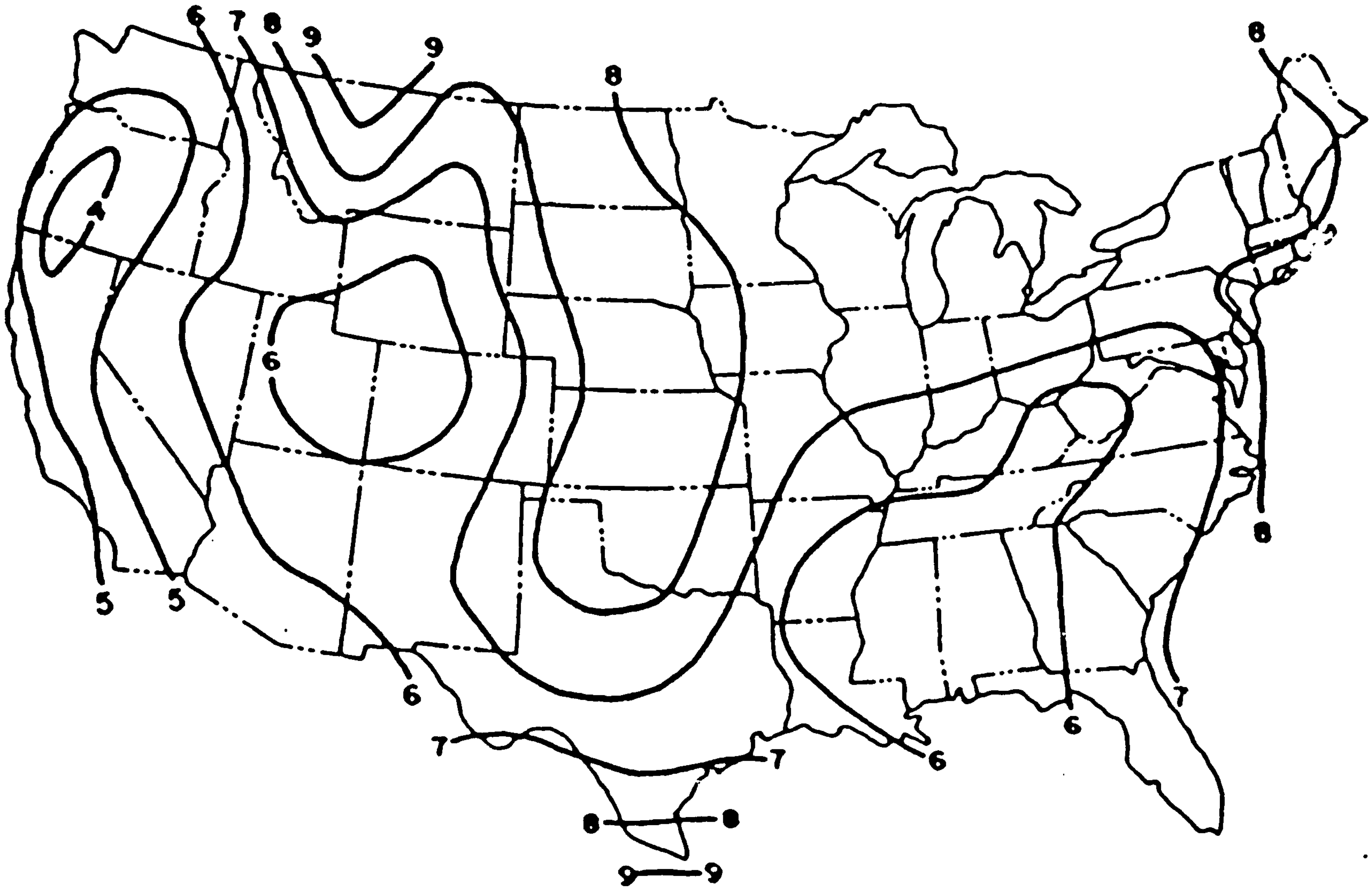


Figure 1 Mean annual wind speed averaged through the afternoon mixing layer. Speeds in meters/seco:d. (From Fundamentals of Air Pollution, 2nd Edition, by A.C. Stern e: al., Academic Press, New York, 1984.)

and dose y (in mg/kg) of the reference chemical is required to produce the same effect, the potency of the chemical of interest relative to the reference chemical is given by the equation:

$$\text{Relative Potency} = y/x$$

It is important when determining the relative potency that both dose x and dose y are expressed in units of mg/kg or mg/m^3. Thus, when doses are expressed in molar or ppm units, they must be converted to a gram (mg) basis.

The second method for determining relative potency is when dose x (mg/kg) of the compound of interest produces an effect in time T_1 (hours) and dose x (mg/kg) of the reference chemical causes the same effect in time T_2 (hours), the potency of the chemical of interest relative to the reference chemical is given by:

$$\text{Relative Potency} = T_2/T_1$$

The data base used for determining relative potencies for the DPM is the Registry of Toxic Effects of Chemical Substances (RTECS) (Tatken and Lewis, 1983, Lewis and Sweet, 1985). RTECS was chosen as it is considered to be the most extensive and regularly updated source of toxicological data. Exact matches of biological tests may be found in the RTECS to compare a chemical with the standard (BaP) for determining the relative potency. However, in many cases there are not enough exact matches of biological tests. If appropriate matches are not available, a secondary standard must be used. The secondary standard should be structurally as similar to the chemical of interest as possible. The secondary standards chosen for the DPM application of the RASH method are benzene, cadmium (Cd) and N-nitrosodimethylamine (DMNA). When using secondary standards, the potency of the chemical of interest relative to BaP is determined by:

$$\text{Relative Potency} = (D_{BaP}/D_{SS}) \times (D_{SS}/D_{test})$$

where:

D_{BaP}/D_{SS} = Potency of secondary standard relative to benzo[a]pyrene
D_{SS} = Dose of secondary standard
D_{test} = Dose of chemical of interest

Values for (D_{BaP}/D_{SS}) are:

$(D_{BaP}/D_{SS})_{benzene} = 0.0050$
$(D_{BaP}/D_{SS})_{DMNA} = 0.079$
$(D_{BaP}/D_{SS})_{Cd} = 0.23$

Chemicals that have been well tested may have more than 20 listings in the RTECS while common industrial chemicals may have between 6 and 20 entries. The relative potencies calculated from the respective entries may vary considerably. An example of the various relative potency estimates for unsymmetrical dimethylhydrazine (UDMH) and the variety of biological test data in RTECS are shown in Table H-1. The standard RTECS test abbreviations are shown in Table H-2.

Table 6. Waste containment effectiveness factors for air/soil pathways

Description	Score
Closed (inactive) landfills	
Landfill covered with compacted clay cap which is in good condition; barometric pumping of landfill vented to VOC control system; landfill surface covered with vegetation to prevent fugitive dust emissions.	0.1
Landfill covered with compacted clay cap which has little or no damage; landfill vented to atmosphere; vegetation cover or dust suppression system used to prevent fugitive dust emissions.	0.5
Landfill covered with compacted clay cap; no vegetation or dust suppression system to control fugitive dust emissions.	0.8
Landfill lacks clay cap and soil cover.	1.0
Open (active) landfills	
Daily cover material applied; fugitive dust suppression system used during operations.	0.4
Daily cover material applied, little/no fugitive dust suppression used during operations.	0.8
No daily cover material applied, no fugitive dust suppression system used.	1.0
Contaminated soil	
Contaminated area completely covered by permanent structure such as a paved surface or building.	0.2
50% or more of contaminated area covered and fugitive dust suppression system used.	0.5
Contaminated area less than 50% covered or fugitive dust suppression system used.	0.8
No covering of contaminated area and no fugitive dust suppression system used.	1.0

Table 6. Waste containment effectiveness factors for air/soil pathways (continued)

Description	Score
Waste piles	
Waste pile located indoors in a closed structure with air pollution control on the building vent.	0.1
Outdoors but covered with physical barrier (e.g. tarp).	0.4
Uncovered outdoors, but treated with dust suprressant.	0.6
Open to atmosphere, no cover or dust suppression used.	1.0
Surface impoundments	
Impoundment enclosed with sealed structure and gases vented to control device; or, surface covered with floating synthetic membrane.	0.3
Deep, quiescent, non-agitated; or, shallow, quiescent, non-agitated with wind barrier.	0.5
Shallow, quiescent; non-agitated.	0.7
Agitated.	0.8
All other impoundments.	1.0

Contaminant Hazard Scoring--Air/Soil Pathways

The first step in scoring the contaminant hazard for sites where contaminants have been detected is to fill out the Air/Soil Hazard Worksheet. Contaminants are considered detected if: (1) contaminant has been detected from ambient air quality monitoring or (2) volatile contaminant has been detected in soil or surface impoundment. The Air/Soil Hazard Worksheet follows the same similar procedures as for the Hazard Worksheet.

In column 1 of the Air/Soil Hazard Worksheet, list the contaminants detected. If the contaminant was detected by ambient air monitoring, list in column 2 for each contaminant, the concentration detected in units of g/m^3. If the contaminant was detected at the site (in soil or surface impoundment), use the appropriate model to predict emission rate of the contaminant in g/s. Use the modeled emission rate with the air quality model to determine the air concentration in g/m^3 and enter result in column 2.

In column 3 of the Air/Soil Hazard Worksheet, enter the soil concentration for each contaminant detected in mg/Kg soil. (This does not apply to surface impoundments).

Use the fugitive dust model for wind erosion to predict the emission rate of fugitive dust in g/s from the site being scored. Note that this model determines the total emission rate for fugitive dust, not for each constituent. Use the modeled emission rate with the air quality model to determine the air concentration of fugitive dust in g/m^3 and enter the result in column 4.

Consult Appendix B to obtain the health effects and terrestrial effects benchmarks for each contaminant and list the benchmarks in columns 5 and 6 respectively. Determine benchmarks in the same manner as is done for the Hazardous Worksheet. Appendix D should be consulted for contaminant values needed to compute hazard scores.

Calculate the inhalation intake for each contaminant by summing the VOC air concentration (column 2) and the fugitive dust concentration (column 3) and multiplying the sum by an average inhalation rate of 20 m^3/day and assuming 100% absorption of each contaminant. Note that the fugitive dust concentration is for total particulates. This must be converted to the contaminant concentration by assuming that the air borne particulates have the same contaminant concentration as the soil. Refer to the Air Hazard Worksheet for the exact calculation. Enter the result in column 7.

Calculate the soil ingestion rate for each contaminant by multiplying the soil concentration (column 3) by the soil ingestion rate for children of 0.165 g soil/day (1). Refer to the Air Hazard Worksheet for the exact calculation. Enter the result in column 8. Enter the total daily intake for each contaminant in micrograms/day (sum of column 7 and column 8) in column 9.

Calculate the health hazard quotient for each contaminant by dividing the total intake (column 9) by the health hazard benchmark (column 5). Enter the result in column 10. Calculate the terrestrial hazard quotient for each contaminant by dividing the air concentration (VOC and from fugitive dust) by the terrestrial effects benchmark (column 6). Refer to the Air Hazard Worksheet for the exact calculation. Enter the result in column 11. Sum the values in both column 10 and column 11 (assume missing values to be zero) and calculate the logarithm of each sum. Calculate the human health hazard score by the same procedure as described for surface water and groundwater pathways. Using the terrestrial hazard quotient, calculate the ecological hazard score by the same procedure as described for surface water and groundwater pathways.

AIR/SOIL RECEPTORS

Human Health Receptors

Population within a 4 mile radius is an indicator of the population which may be harmed from hazardous substances released to the air. The distance is measured from the location of the site, not the facility boundary. The population to be counted includes persons residing within the four-mile radius as well as transients such as workers in factories, offices, restaurants, motels, or base employees. It excludes travelers passing through the area. Select the highest value for this as follows:

Population	0-4 miles	0-1 mile	0-1/2 mile	0-1/4 mile
0	0	0	0	0
1 to 100	9	12	15	18
101 to 1000	12	15	18	21
1001 to 3000	15	18	21	24
3001 to 10,000	18	21	24	27
More than 10,000	21	24	27	30

Land use indicates the nature and level of human activity in the vicinity of the site. Assign the highest applicable score as follows:

Score =	0	1	2	3
Distance to Commercial-Industrial	> 1 mile	1/2 to 1 mile	1/4 to 1/2 mile	< 1/4 mile
Distance to National/State Parks, Forests, Wildlife Reserves, and Residential Areas.	> 2 miles	1 to 2 miles	1/4 to 1 mile	< 1/4 mile

The distance to nearest installation boundary is an indicator of the potential for humans to come into contact with contaminants other than from inhalation. Measure the shortest linear distance from the edge of the contaminated area to the installation boundary. Assign a score as follows:

Distance to installation boundary	Score
> 2 miles (> 3.2 km)	0
1 to 2 miles (1.6 to 3.2 km)	1
3000 ft to 1 mile (0.9 to 1.6 km)	2
< 3000 ft (< 0.9 km)	3

Ecological Receptors

Distance to sensitive environment is an indicator of the likelihood that a region that contains important biological resources or that a fragile natural setting would suffer serious damage if hazardous substances were to be released from the facility. Assign scores as follows:

Score =	0	1	2	3
Distance to Wetlands (5 acre minimum)				
Coastal	>2 miles	1 to 2 miles	1/2 to 1 miles	<1/2 mile
Fresh water	>1 mile	1/4 to 1 mile	100 ft to 1/4 mi	<100 ft
Distance to Critical Habitat (of endangered species)	>1 mile	1/2 to 1 mile	1/4 to 1/2 mile	<1/4 mile

Presence of "critical environments" within 1 mile (1.6 km) of the site in any direction is an indicator of the potential for harm to the unusually sensitive ecological receptors. "Critical environments" are defined to include lands or waters specifically recognized or managed by federal, state, or local government agencies or private organizations as rare, unique, unusually sensitive, or important natural resources (including designated critical habitat for endangered species, wilderness areas, nature preserves, or wildlife sanctuaries, but not parks established for historic preservation or recreation); and habitat utilized by any federally designated endangered species on a permanent or seasonal basis. Assign scores as follows:

Presence of critical environments	Score
Critical environments absent	0
Critical environments present	1

AIR QUALITY MODELING

In some cases, ambient air monitoring may provide air concentrations for contaminants. These concentrations can be used for the Air Hazard Worksheet to determine the health hazard quotient. If ambient air concentrations are not available, they must be predicted by air quality modeling.

To predict ambient air concentrations for a contaminant, emission rates for that contaminant must be determined. The enclosed models can be used to predict VOC emission rates from closed landfills; open landfills, waste piles, soil contamination; and surface impoundments as well as fugitive dust emissions from wind erosion. These sources are all considered as area sources. The models all assume a constant emission rate from an infinite supply source.

For modeling emissions from an area source, the emission source is considered as a virtual point source with emissions at ground level and negligible plume rise. The virtual point source is located at a distance upwind from the area source such that the horizontal dispersion downwind of the point source is equal to the width of the area source.

The model used is one that has been evaluated and recommended elsewhere (2,3). This model is considered a screening model which is a simple Gaussian dispersion technique to provide preliminary concentration estimates. More refined models are available, but they are too complex to be used for this project. The downwind concentration is estimated by:

$$X = 16*(2Q)/[2*pi*L_v*(2*pi)^{0.5}*sigz*u]$$

where

- X = Centerline concentration of pollutant L meters downwind of source, in g/m^3
- Q = Emission rate of pollutant from emission source, in g/sec
- L_v = Virtual downwind distance to receptor, in m = $L + L'$
- L = Distance from center of area source to receptor (= 100 m), in m
- L' = Distance from center of area source to upwind virtual point source, in m = $2.63*w$
- w = Width of the area source perpendicular to the wind, in m
- sigz = Vertical dispersion coefficient, in m = $0.14*L^{0.78}$
- u = Annual average wind speed, in m/s

The value for the emission rate; Q, is found from the models for VOC and fugitive dust emissions. The value for L, the distance from the center of the area source to the downwind receptor, is taken as 100 meters, the minimum value allowed. If the effective diameter of the area source has been calculated (de), that may be used for w, the width of the area source.

OPEN LANDFILLS/WASTE PILES/SOIL

It is believed that similar mechanisms are involved in emissions of volatile organic compounds from open landfills, waste piles, and soil. These emissions can be estimated by applying Fick's second law of diffusion to an infinite slab. This model assumes that the volatile organics volatilize in the void spaces in the soil. The vapor diffuses through the soil to the surface. Crank gives a general solution to applying Fick's second law to an infinite slab in the form of an infinite series as (4):

$$F = 1 - \sum_{n=0}^{\infty} \left[\frac{8}{(2n-1)^2 \pi^2} \right] \exp\left[\frac{-D(2n+1)^2 \pi^2 t}{4l^2} \right]$$

where:

F = Fraction of volatile compound emitted after time t
D = Diffusion coefficient of the constituent in air
l = Distance from center to surface of slab

As the diffusion is through a porous media, an effective diffusion coefficient must be calculated in relation to the diffusion coefficient of the component in air and the porosity of the soil (assuming dry soil) as:

$$D_e = D * \varepsilon^{4/3} (T_a/T_r)^{1.5}$$

where:

D_e = The effective diffusion coefficient through the soil
D = Diffusion coefficient of the constituent in air
ε = Total porosity of the soil
T_a = Actual temperature
T_r = Reference temperature

Crank's solution has been approximated to estimate emissions of volatile organics after short periods of time from open landfills, waste piles, or soil as (5):

$$F = 0.72 \ (K_d t)^{0.5}$$

where:

K_d = Volatilization constant

After longer time periods, Crank's solution has been approximated as (5):

$$F = (8/\pi^2) \ [\ 1 - \exp(-K_d t)\ ] + 0.1878$$

The instantaneous emission rate of volatile organics from open landfills, waste piles, or soil can be found by differentiating the above equations for the fraction emitted.

The resulting equation giving the instantaneous emission rate after short times is:

$$E = Mo/l \left[\frac{1}{(\varepsilon/k_G\ K_{eq}) + (\pi t/K_{eq}\ D_e)^2} \right]$$

where:

E = Instantaneous emission rate of constituent
Mo = Initial area loading of constituent
ε = Soil porosity
k_g = Gas-phase mass transfer coefficient
K_{eq} = Equilibrium coefficient
D_e = Effective diffusion coefficient

After longer time periods, the instantaneous emission rate is given by:

$$E = (2Mo\ K_{eq}\ D_e/l^2)\ [\exp(-\tau)]$$

where:

E = Instantaneous emission rate of constituent
Mo = Initial area loading of constituent
K_{eq} = Equilibrium coefficient
D_e = Effective diffusion coefficient
l = Depth of waste in soil
τ = Decay constant

A flow sheet for calculating VOC emission rates from open landfills, waste piles, and contaminated soil is given in Figure 2. The equations required from the flow sheet are on the pages following Figure 2. The VOC emission rate is calculated as the instantaneous emission rate after one day using the emission rate equation for after short times. This assumes a constant emission rate equal to the emission rate after one day with an infinite source.

The model assumes no loss of volatile organic compounds from biodegradation or adsorption onto soil particles. The model also assumes that the waste is uniformly mixed.

The following inputs are required for modeling volatile emissions from open landfills, waste piles, and soil:

A: Surface area of landfill, waste pile, or contamination, in cm^2
l: Depth of waste in soil, in cm
T: Average soil temperature, in ^oK
E_a: Total soil porosity
L: Waste loading of soil, in g/cm^3

If average soil temperature data is unavailable, assume that the average soil temperature is equal to the mean annual ambient temperature.

Waste loading is the grams of organic waste per cubic centimeter of soil. If a dry fixative is added to a waste mixture before placing the waste into a landfill or w stepile and waste mixture composition is known, calculate L as (for example):

Waste liquid composition:	x% volatile A
	y% volatile B
	z% aqueous

Liquid waste density before adding fixative = rho

Assume that 1 cm^3 + fixative = 1 cm^3 fixed waste

L = gram organic phase/cm^3 fixed waste
= (x%/100 + y%/100) x rho

Weight fraction for constituent x and y would be:
$C_x = x/(x + y)$ $C_y = y/(x + y)$

If the above data is unavailable but concentration of waste (for each constituent) at the site is available, use that data such that:

L = concentration of waste in grams/cm^3 soil
C = weight fraction of constituent = 1.

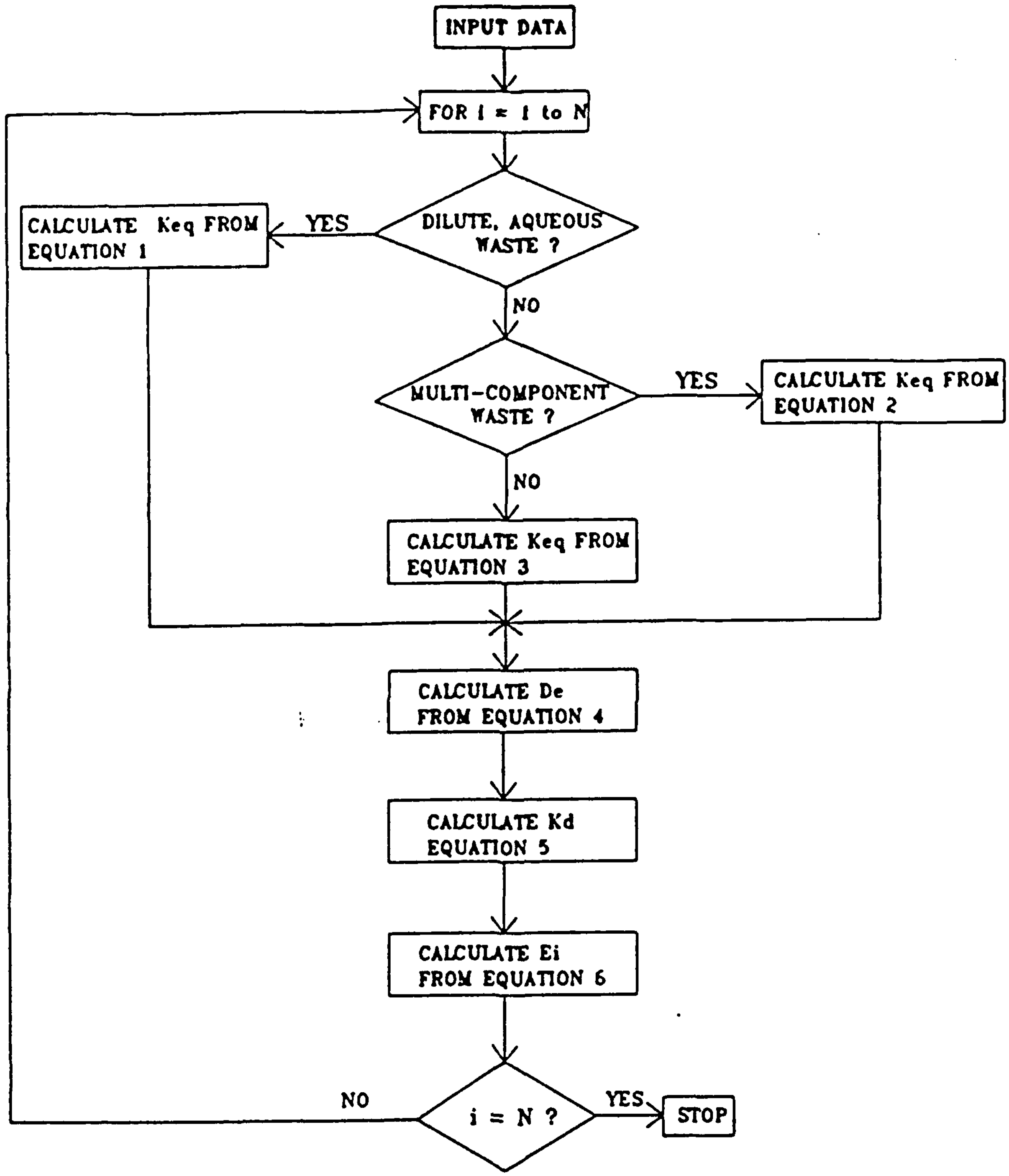
If soil concentration for each constituent is expressed in units of ug/kg soil (or similar units), this should be converted to units of g/cm^3. Thus soil density of the site is needed. If the soil density for the site is not available, assume the following approximate values:

clay	1.8 g/cm^3
light soil with roots	0.3 g/cm^3
wet sand soil	1.6 g/cm^3

For each volatile organic constituent in the waste mixture, the following is required (as input data and/or in a data base):

C_i: Mass fraction of constituent in original waste mixture
MW: Molecular weight of constituent
Hc: Henry's law constant, in atm m^3/mol
Da: Diffusion coefficient of constituent in air, in cm^2/s
p_*: Density
P^*: Pure component vapor pressure of constituent, in atm

FIGURE 2
OPEN LANDFILL/WASTE PILE/SOIL



EQUATIONS FOR OPEN LANDFILL/WASTE PILE/SOIL

Equation 1

K_{eq} = $[(H_c)(10^6 cm^3/m^3)]/(RT) \times E_a/E_{waste}$

Where:

K_{eq} = Equilibrium coefficient
H_c = Henry's law constant for constituent i, in atm m^3/g mol
R = Ideal gas constant, 82.05 atm cm^3/g mol ^oK
T = Temperature of vapor in soil, in ^oK
E_a = Soil porosity, from input data
E_{waste} = L/p
L = Waste loading in soil from input data, in g waste/cm^3 soil
p = Average density of liquid waste, in g/cm^3

Equation 2

K_{eq} = $(P^* MW_{ave})/(RT) \times E_a/L$

Where:

K_{eq} = Equilibrium coefficient
P^* = Pure component vapor pressure, in atmospheres
R = Ideal gas constant, 82.05 atm cm^3/g mol ^oK
T = Temperature of vapor in soil, in ^oK
E_a = Soil porosity, from input data
L = Waste loading in soil, from input data, in g waste/cm^3 soil
MW_{ave} = Average molecular weight of the waste mix not including component i given by:
MW_{ave} = [(Summation from 1 -> N (MW_N)) - MW_i] / (N-1)

Equation 3

K_{eq} = $(P^* MW)/(RT) \times E_a/L$

Where:

K_{eq} = Equilibrium coefficient
P^* = Pure component vapor pressure, in atmospheres
R = Ideal gas constant, 82.05 atm cm^3/g mol ^oK
T = Temperature of vapor in soil, in ^oK
E_a = Soil porosity, from input data
L = Waste loading in soil, from input data, in g waste/cm^3 soil
MW = Molecular weight of the waste

EQUATIONS FOR OPEN LANDFILL/WASTE PILE/SOIL

Equation 4

$$D_e = D_a*E_a^{4/3}*(T_{act}/T_{ref})^{1.5}$$

Where:

D_e = Effective diffusion coefficient
D_a = Diffusion coefficient of constituent in air at reference temperature, in cm^2/s
E_a = Soil porosity, from input data
T_{act} = Actual temperature, in ^oK
T_{ref} = Reference temperature for D_a, in ^oK

Equation 5

$$K_d = (K_{eq}*D_e*pi^2)/(4l^2)$$

Where:

K_d = Volatilization constant in, s^{-1}
l = depth of waste in soil, in cm

Equation 6

$$E_i = M_o/l*[1/((E_a/k_GK_{eq})+(t*pi/K_{eq}D_e)^{.5})]*A$$

Where:

E_i = Emission rate of constituent i at time t in g/s
M_o = Area loading of constituent, g/cm^2
= $l*L*C$
l = Depth of waste in soil in cm
L = Waste loading in soil from input data in g waste/cm^3 soil
C_i = Weight fraction of constituent i in waste mix
E_a = Soil porosity, from input data
A = Surface area of contaminated area, in cm^2
k_G = Gas-phase mass transfer coefficient

$$k_G = 4.82*(10^{-3})*U^{0.78}*Sc_G^{-0.67}*de^{-0.11}$$

U = Wind velocity in m/s
Sc_G = Schmidt number
= $u_a/(p_a*D_a)$
u_a = Viscosity of air, g/cm s
p_a = Density of air, g/cm^3
D_a = Diffusion coefficient of constituent in air in cm^2/s
d_e = Effective diameter of land area in m
= $(4*Area/pi)^{1/2}$
t = time, in seconds
= 86,400 s (1 day)

CLOSED LANDFILLS

Estimating emissions of volatile organic compounds from closed landfills can be estimated from Fick's first law for steady-state diffusion. The model assumes that the compound volatilizes in the void spaces in the soil. The concentration of the volatile in the vapor is assumed to reach equilibrium. The vapor diffuses through the waste and the landfill cap to the surface of the landfill. The driving force for the diffusion is the difference between the concentration of the volatile in the void spaces and the landfill surface (which is assumed to be equal to 0). The resulting equation for the flux of the volatile organic from the landfill is:

$$J = -D_e*(C_A - C_s)/l$$

where:

J = Vapor flux rate of constituent through soil/cap, in g/cm^2 s
D_e = Effective diffusion coefficient through soil/cap
C_A = Concentration of constituent at landfill surface
C_s = Concentration of constituent in void spaces

The emission rate from the landfill of volatile compounds from diffusion alone is given by:

$$E = J \times A$$

where:

E = Emission rate of constituent in g/s
J = Flux rate from diffusion of constituent, in g/cm^2 s
A = Surface area of landfill, in cm^2

As the diffusion of the vapor is through a porous media, an effective diffusion coefficient must be calculated in relation to the diffusion coefficient of the component in air and the porosity of the soil/landfill cap as:

$$D_e = D*e^{4/3}*(T_a/T_r)^{1.5}$$

where:

D_e = Effective diffusion coefficient through soil/cap
D = Diffusion coefficient of constituent in air
e = Total porosity of soil/cap
T_a = Actual temperature
T_r = Reference temperature of D

The landfill cap porosity is assuming total porosity for dry material.

The vapor concentration of the constituent in the void spaces is found by applying the ideal gas law as:

$$C_s = P_i * MW / R * T$$

where:

C_s = Concentration of constituent in vapor in void space
P_i = Equilibrium partial pressure of constituent determined either by Raoult's law or Henry's law
MW = Molecular weight of constituent

The model also estimates emissions of volatile compounds if the landfill is vented by barometric pumping. The emission rates from diffusion and barometric pumping are added to determine the initial total emission rate.

A flow sheet for calculating VOC emissions from closed landfills is given in Figure 3. The equations referred to in the flow sheet are found on the pages following Figure 3. The VOC emission rate is calculated as the initial emission rate at the time of closure assuming an infinite source supply.

The following inputs are required for modeling volatile emissions from closed landfills:

A: Surface area of landfill, in cm^2
l: Thickness of landfill cap, in cm
D: Waste bed thickness, in cm
T: Average temperature, in ^oK
e: Porosity of landfill cap

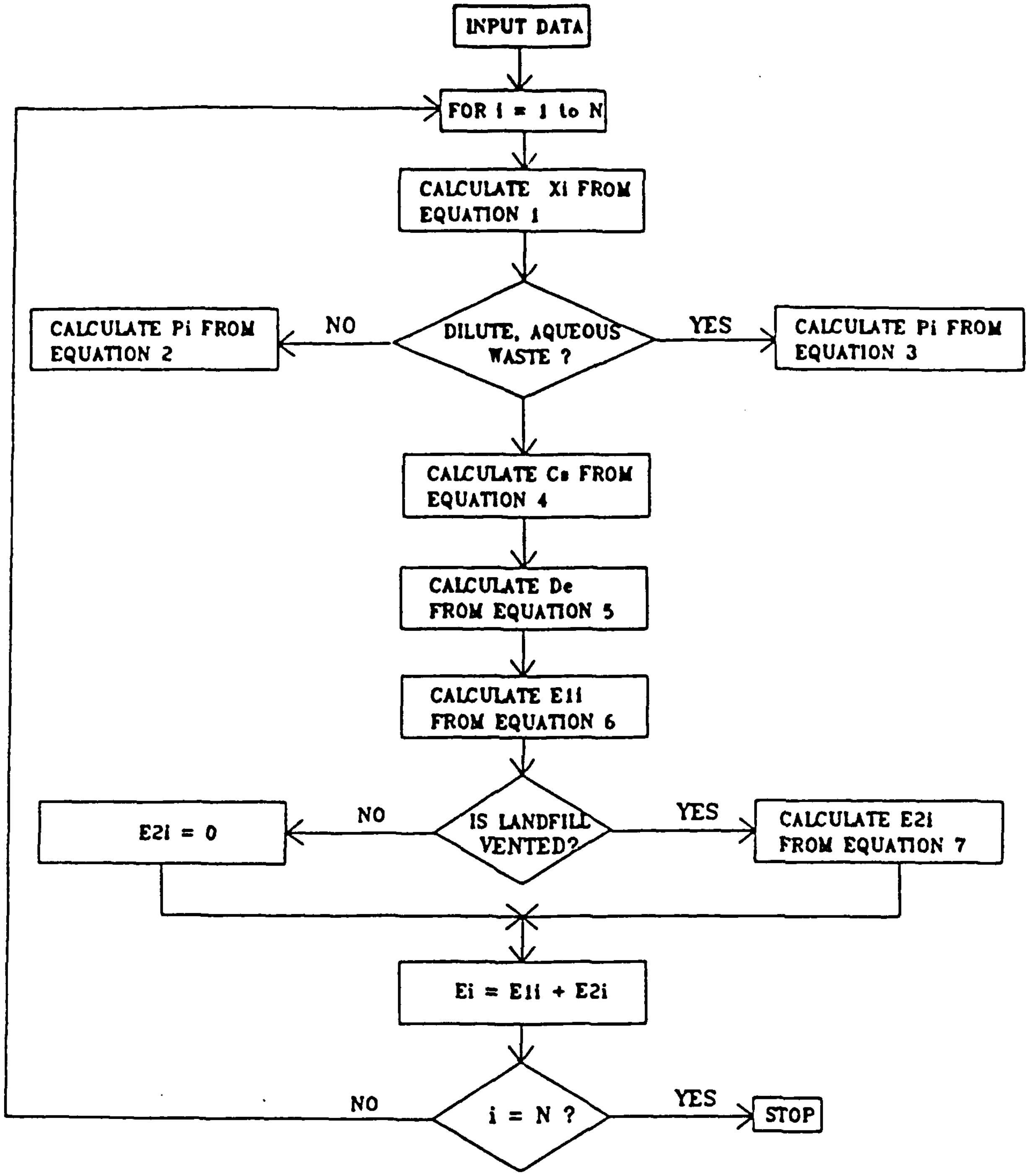
If barometric pumping is considered, the following additional inputs are required:

t_d: Time interval to determine average pumping rate, in s
P_r: Reference barometric pressure, in mm Hg
P_1: Final barometric pressure after t_d, in mm Hg
T_r: Reference temperature, in ^oK
T_1: Final temperature in landfill after t_d, in ^oK
e_w: Air porosity of fixed waste in landfill

For each volatile organic constituent in the waste mixture, the following is required (as input data and/or in a data base):

C_i: Mass fraction of constituent in original waste mixture
MW: Molecular weight of constituent
P^*: Pure component vapor pressure of constituent, in atm
Hc: Henry's law constant, in atm m^3/mol
Da: Diffusion coefficient of constituent in air, in cm^2/s

FIGURE 3
CLOSED LANDFILL



EQUATIONS FOR CLOSED LANDFILL

Equation 1

$X_i = (C_i/MW_i)/MW_{ave}$

Where:

X_i = Mole fraction of constituent i in original waste mixture

C_i = Mass fraction of constituent i in original waste mixture

MW_i = Molecular weight of constituent i

MW_{ave} = Average molecular weight of original waste = Summation from 1 -> N (C_n*MW_n)

Equation 2

$P_i = X_i*P^*$

Where:

P_i = Equilibrium vapor pressure of constituent i, in atmospheres

X_i = Mole fraction of constituent i in original waste mixture

P^* = Pure component vapor pressure of component i, in atmospheres

Equation 3

$P_i = (H_{ci}*p*X_i)/MW \times 10^6\ cm^3/m^3$

Where:

P_i = Equilibrium vapor pressure of constituent i, in atmospheres

X_i = Mole fraction of constituent i in original waste mixture

H_{ci} = Henry's law constant for constituent i, in atm m^3/mol

p = Density of dilute aqueous waste liquid, in g/cm^3, generally equal to 1 g/cm^3

MW = Average molecular weight of dilute aqueous waste liquid, generally equal to 18 g/g mol

EQUATIONS FOR CLOSED LANDFILL

Equation 4

$C_{si} = (P_i * MW_i)/(R * T)$

Where:

C_{si} = Concentration of constituent i in the gas within the landfill, in g/cm^3 gas

P_i = Equilibrium vapor pressure of constituent i, in atmospheres

MW_i = Molecular weight of constituent i

R = Ideal gas constant, 82.05 cm^3 atm/g mol ^oK

T = Temperature within landfill, ^oK

Equation 5

$D_{ei} = D_{ai} * E_a{}^{4/3} * (T_{act}/T_{ref})^{1.5}$

Where:

D_{ei} = Effective diffusion coefficient, in cm^2/s

D_{ai} = Diffusion coefficient of constituent i in air at reference temperature, in cm^2/s

E_a = Landfill cap (soil) porosity, from input data

T_{act} = Actual temperature, in ^oK

T_{ref} = Reference temperature for D_a, in ^oK

Equation 6

$E_{1i} = D_{ei} * C_{si} * A/l$

Where:

E_{1i} = Initial emission rate of constituent i at landfill closure from diffusion, in g/s

D_{ei} = Effective diffusion coefficient, in cm^2/s

C_{si} = Concentration of constituent i in the gas within the landfill, in g/cm^3 gas

A = Surface area of landfill, in cm^2

l = Thickness of landfill cap, in cm

EQUATIONS FOR CLOSED LANDFILL

Equation 7

$$E_{2i} = Q*C_{si}*A$$

Where:

E_{2i} = Initial emission rate of constituent i from barometric pumping of landfill, in g/s

C_{si} = Concentration of constituent i in the gas within the landfill, in g/cm^3 gas

A = Surface area of landfill, in cm^2

Q = Average flow rate of gas from landfill vent from barometric pumping, in cm^3/cm^2 landfill area s

= $V_B/(A*t_d)$

t_d = Time interval to determine average barometric pumping rate, in s

$$V_B = V_C[(P_r/P_1)(T_1/T_r) - 1]$$

P_r = Reference barometric pressure, mm Hg

P_1 = Final barometric pressure after time interval, mm Hg

T_1 = Final temperature in landfill after time interval in ^oK

T_r = Reference temperature in landfill, in ^oK

$$V_C = D*A*E_W$$

V_C = Volume of total void space within waste, in cm^3

D = Waste bed thickness in landfill, in cm

E_W = Air porosity of fixed waste in landfill

SURFACE IMPOUNDMENTS

Emissions of volatile organic compounds from surface impoundments and open tanks can be estimated based on mass transfer theory. The basic relationship describing the mass transfer of a volatile compound from an open liquid surface is given by:

$$E = K*A*C_l$$

where:

- E = Emission rate from the liquid surface
- K = Overall mass transfer coefficient
- A = Liquid surface area
- C_l = Concentration of volatile in the liquid

The overall mass transfer coefficient assumes a two phase resistance model consisting of a liquid-phase and a gas-phase resistance. The resistances are represented by a liquid-phase mass transfer coefficient (k_l) and a gas-phase mass transfer coefficient (k_g) along with a partition coefficient (K_{eq}). The two resistances act in series to provide an overall resistance of:

$$1/K = 1/k_l + 1/(k_g*K_{eq})$$

The liquid-phase mass transfer coefficient is calculated by empirical relationship, dependant upon wind speed, fetch-to-depth ratio, and diffusivity of the compound in water. The gas-phase mass transfer is calculated by an empirical relationship which is a function of wind speed, effective diameter of the liquid surface, and the diffusivity of the compound in air.

The driving force for the mass transfer process is the difference between the concentration of the volatile in the liquid-phase (C_l) and the concentration of the volatile in the gas-phase (assumed to be 0). For a flow through system, the liquid concentration is estimated from a mass balance on the system of:

$$Q*Co = K*A*C_l + Q*C_l$$

where

- Q = Volumetric flow rate
- Co = Initial concentration of the volatile in the waste
- C_l = Liquid concentration of the volatile

$Q*Co$ represents inlet flow of the volatile compound, $K*A*C_l$ represents the amount volatilized, and $Q*C_l$ represents the outlet flow.

For a system without flow, the liquid concentration is assumed to be equal to the initial concentration, thus assuming an infinite source.

The models for surface impoundment emissions assume no biodegradation, no mechanical aeration, and that the waste is well mixed.

A flow sheet for calculating VOC emission rates from surface impoundments is given in Figure 4. The equations referred to in the flow sheet are on the pages following Figure 4.

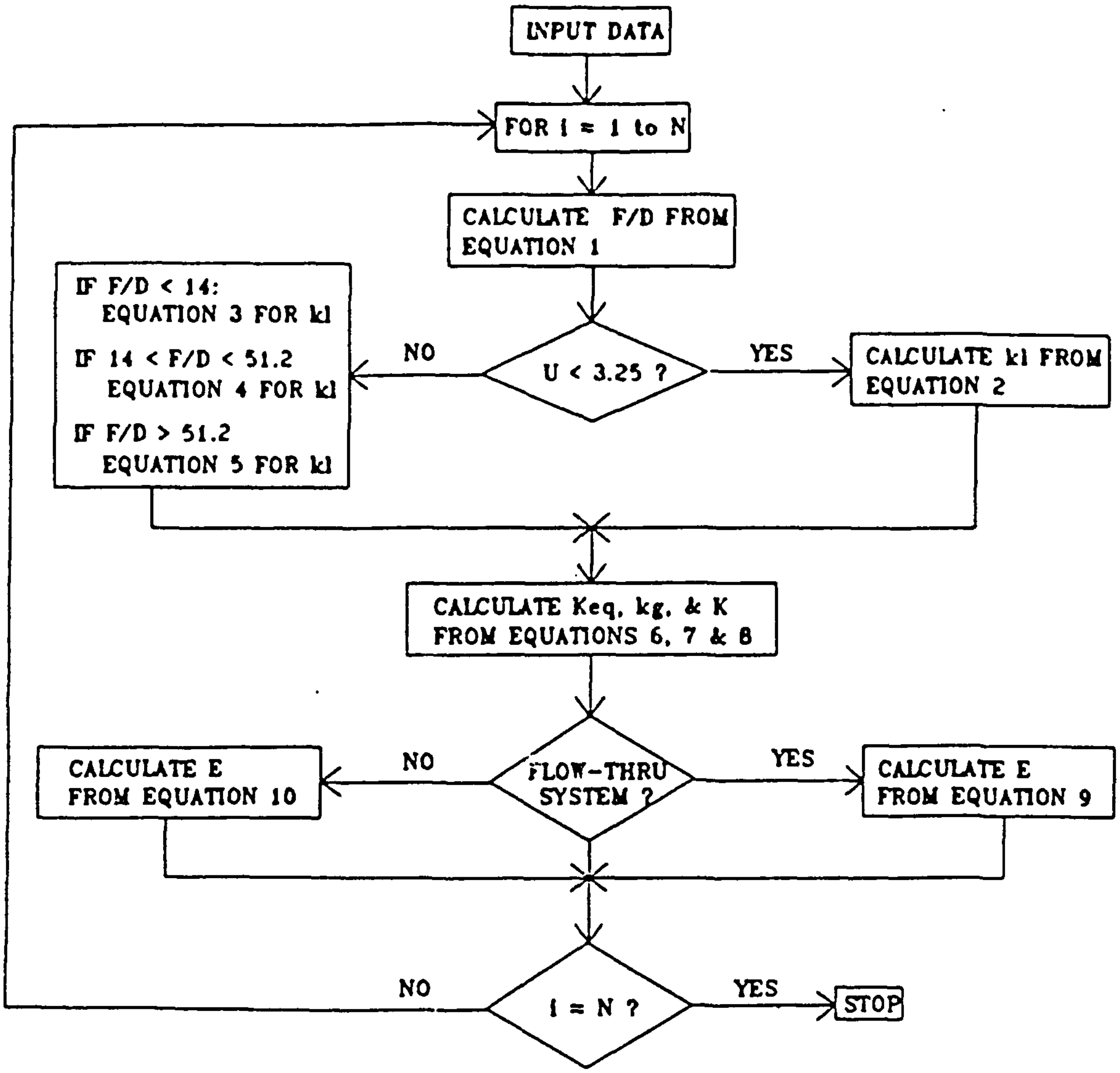
The following inputs are required for modeling volatile emissions from surface impoundments:

- A : Surface area, in cm^2
- Depth: Depth of the surface impoundment/tank, in cm
- U : Wind velocity, in m/s
- T : Temperature, in ^oK
- t_{ret} : Average retention time in impoundment, in sec (for surface impoundments with flow)

For each constituent of the waste, the following is required (as input and/or in a data base):

- Co : Initial concentration in the waste, in g/m^3
- D_w : Diffusivity of the constituent in water, in cm^2/s
- D_a : Diffusivity of the constituent in air, in cm^2/s
- H : Henry's law constant, in atm m^3/g mol

FIGURE 4
SURFACE IMPOUNDMENTS



EQUATIONS FOR SURFACE IMPOUNDMENTS

Equation 1

F/D = Fetch/Depth

Where:

Fetch = Linear distance across the liquid surface in the direction of the wind flow, in cm
= de

de = Effective diameter of impoundment, in cm
= $[(4*A)/pi]^{0.5}$

A = Surface area of impoundment, in cm^2

Depth = Average depth of impoundment, in cm

Equation 2

$k_l = 2.78 \times 10^{-6}*[D_{w,i}/D_{eth}]^{2/3}$

Where:

k_l = Liquid-phase mass transfer coefficient, in m/s

$D_{w,i}$ = Diffusivity of constituent in water, in cm^2/s

D_{eth} = Diffusivity of ether in water, in cm^2/s
= 8.5×10^{-6} cm^2/s

Equation 3

If $U^* > 0.3$:

$k_l = 1.0 \times 10^{-6} + 34.1 \times 10^{-4}*(U^*)*Sc_L^{-0.5}$

If $U^* < 0.3$:

$k_l = 1.0 \times 10^{-6} + 144.1 \times 10^{-4}*(U^*)^{2.2}*Sc_L^{-0.5}$

Where:

U^* = Friction velocity, m/s
= $0.01*U*(6.1 + 0.63*U)^{0.5}$

U = Wind speed at 10 meters above surface, m/s

k_l = Liquid-phase mass transfer coefficient, in m/s

Sc_L = Schmidt number on liquid side
= $u_L/(p_l*D_{wi})$

u_L = Viscosity of water, g/cm s

p_l = Density of water, g/cm^3
= 1 g/cm^3

D_{wi} = Diffusivity of constituent i in water, in cm^2/s

EQUATIONS FOR SURFACE IMPOUNDMENTS

Equation 4

$$k_l = [2.605 \times 10^{-9}*(F/D) + 1.277\times10^{-7}]*U^2*(D_w/D_{eth})^{2/3}$$

Where:

k_l = Liquid-phase mass transfer coefficient, in m/s
F/D = Fetch-to-depth ratio
U = Wind speed at 10 meters above surface, m/s
$D_{w,i}$ = Diffusivity of constituent in water, in cm^2/s
D_{eth} = Diffusivity of ether in water, in cm^2/s
= $8.5 \times 10^{-6}\ cm^2/s$

Equation 5

$$k_l = [2.611 \times 10^{-7}*U^2*(D_w/D_{eth})^{2/3}$$

Where:

k_l = Liquid-phase mass transfer coefficient, in m/s
U = Wind speed at 10 meters above surface, m/s
$D_{w,i}$ = Diffusivity of constituent in water, in cm^2/s
D_{eth} = Diffusivity of ether in water, in cm^2/s
= $8.5 \times 10^{-6}\ cm^2/s$

Equation 6

$$K_{eq} = H/RT$$

Where:

K_{eq} = Partition coefficient
H = Henry's law constant for constituent i, in atm m^3/g mol
R = Universal gas constant, in atm m^3/g mol ^oK
= 8.21×10^{-5} atm m^3/g mol ^oK
T = Temperature, in ^oK

Equation 7

$$k_G = 4.82 \times 10^{-3}*U^{0.78}*Sc_G^{-0.67}*de^{-0.11}$$

Where:

k_G = Gas-phase mass transfer coefficient, in m/s
U = Wind speed at 10 meters above surface, in m/s
Sc_G = Schmidt number on gas side
= $u_G/(p_G*D_{ai})$
u_G = Viscosity of air, in g/cm s
= 1.81×10^{-4} g/cm s
p_G = Density of air, in g/cm^3
= $1.2 \times 10^{-3}\ g/cm^3$
D_{ai} = Diffusivity of constituent i in air, in cm^2/s
de = Effective diameter of impoundment, in cm
= $[(4*A)/pi]^{0.5}$
A = Surface area of impoundment, in cm^2

EQUATIONS FOR SURFACE IMPOUNDMENTS

Equation 8

$$1/K = 1/k_l + 1/k_g*K_{eq}$$

Where:

K = Overall mass transfer coefficient, in m/s
k_l = Liquid-phase mass transfer coefficient, in m/s
k_G = Gas-phase mass transfer coefficient, in m/s
K_{eq} = Partition coefficient

Equation 9

$$E_i = K*A*C_L$$

Where:

E_i = Emission rate of constituent i from liquid surface, in g/s
K = Overall mass transfer coefficient, in m/s
A = Surface area of impoundment, in m^2
C_L = Concentration of constituent in the liquid phase, in g/m^3
= $Q*C_o/(K*A + Q)$
C_o = Initial concentration of constituent i in waste, in g/m^3
Q = Volumetric flow rate, in m^3/s
= V/t_{ret}
V = Volume of impoundment, in m^3
t_{ret} = Average retention time for waste in impoundment

Equation 10

$$E_i = K*A*C_o$$

Where:

E_i = Emission rate of constituent i from liquid surface, in g/s
K = Overall mass transfer coefficient, in m/s
A = Surface area of impoundment, in m^2
C_o = Initial concentration of constituent i in waste, in g/m^3

Fugitive Dust Emissions

A potential source of emissions of contaminants is from fugitive dust. Fugitive dust can be created from wind erosion of exposed soil, material handling and vehicle traffic on unpaved surfaces. It is assumed that the fugitive dust will have the same contaminant concentration as the soil.

Fugitive dust emissions from waste piles and exposed soil can be calculated based on an emission equation given in AP-42 (6) as:

$$E = 1.9*(s/1.5)*([365-P]/235)*(f/15)*A*1000*(1/86,400)$$

where:

E = Total fugitive dust emission rate, in g/sec
s = silt content of soil, in %
  = 15% if data unavailable
P = Number of days with $\geq$ 0.25 mm (0.01 in) of precipitation/year
f = Percentage of time unobstructed wind speed exceeds 12 mph (5.4 m/s)
A = Exposed surface area of soil, in hectare (1 hectare = 10^4 m^2)

The above expression is for particles $\leq$30 microns in size. The silt content is defined as particles smaller than 75 micrometers in diameter. If this data is unavailable, assume a silt content of 15%. The number of wet days (P) should obtained by local meteorological data. If unavailable, refer to Figure 5.

The number of wet days factors in the natural suppression of fugitive dust emissions on days of at least 0.25 mm precipitation. Dust particles become entrained by turbulent air currents from wind speeds over 12 mph, thus the inclusion of the factor f. If this number is unavailable from local meteorological data, assume a value of 10%.

Activity at the site such as material handling operations and vehicle traffic may also contribute to the fugitive dust emissions. To account for this, if the Site Activity score (item 8 in Air Pathways score sheet) is equal to 2 or 3, multiply the emission rate calculated above (E) by 1.5 for the total fugitive dust emissions from the site.

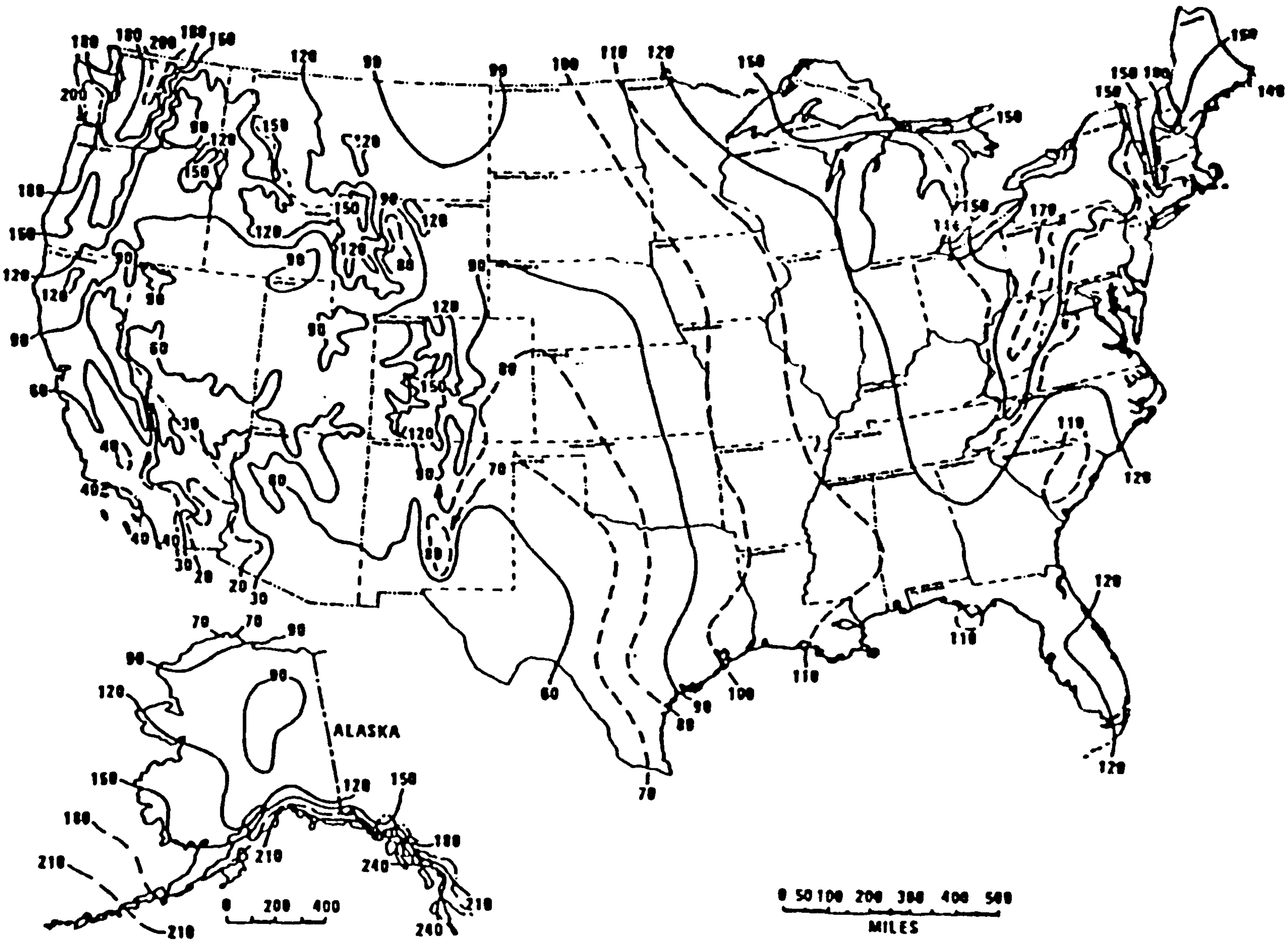


Figure 5. Mean number of days with 0.01 inches or more of precipitation in United States. (From "AP-42: Compilation of Air Pollution Emission Factors," Section 11, US EPA, 1985.)

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